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Prediction of the Hydraulic Jump Location Following A Change of Slope in A Partially Filled Drainage Pipe

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Center for Building Technology
Washington, DC 20234

and

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Department of Building Technology
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PREDICTION OF THE HYDRAULIC JUMP LOCATION FOLLOWING A CHANGE OF SLOPE IN A PARTIALLY FILLED DRAINAGE PIPE

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, ***Secretary***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

ABSTRACT

The criteria governing the formation of a hydraulic jump in a partially filled fluid conduit downstream of a slope change are presented together with the necessary techniques to enable water surface profiles and jump location to be predicted.

Computer programs designed to model the conditions leading to jump formation under flow and channel scale conditions compatible with current drainage system design are presented.

The results of a wide range of test conditions in terms of jump formation and position downstream of a change in channel slope are presented together with a set of criteria to be used in evaluating whether a jump will occur for a given set of design conditions.

PREFACE

This report is one of a group documenting National Bureau of Standards (NBS) research and analysis efforts in developing water conservation test methods, analysis, economics, and strategies for implementation and acceptance. This work is sponsored by the Department of Housing and Urban Development/Office of Policy Development and Research, Division of Energy Building Technology and Standards, under HUD Interagency Agreement H-48-78.

Report prepared by Dr. J. A. Swaffield, guest research worker at NBS-Stevens Institute of Technology from Brunel University, U.K.

TABLE OF CONTENTS

Page

SUMMARY iii
PREFACE iv
NOTATION ix

1.0 INTRODUCTION 1
2.0 THEORETICAL CONSIDERATIONS 3

2.1 Steady Uniform Flow in Open Channels 3
2.2 Gradually Varied Flow in Open Channels 5
2.3 The Hydraulic Jump 8
2.4 Loss Coefficients at Channel Slope Transitions 11

3.0 CALCULATION TECHNIQUES AND PRESENTATION OF RESULTS 12

3.1 Determination of Normal and Critical Depths 12
3.2 Numerical Integration for Surface Profiles 12
3.3 Determination of Jump Location 13
3.4 Presentation of Results 14
3.5 Selection of Input Data 14

4.0 DISCUSSION OF RESULTS 15
5.0 CONCLUSIONS AND FURTHER WORK 20
6.0 REFERENCES 21

APPENDIX 1. JUMP LOCATION IN A 0.075 m DIAMETER PIPE A1.1
APPENDIX 2. JUMP LOCATION, 0.10 m DIAMETER PIPE A2.1
APPENDIX 3. JUMP LOCATION, 0.15 m DIAMETER PIPE A3.1
APPENDIX 4. JUMP LOCATION, 0.075 m WIDE CHANNEL A4.1
APPENDIX 5. JUMP LOCATION, 0.10 m WIDE CHANNEL A5.1
APPENDIX 6. JUMP LOCATION, 0.15 m WIDE CHANNEL A6.1
APPENDIX 7. JUMP FORMATION INDICATOR TABLES FOR CONSTANT MANNING COEFFICIENT OF 0.015 FOR BOTH CIRCULAR AND RECTANGULAR CHANNELS A7.1
APPENDIX 8. JUMP FORMATION INDICATOR TABLES FOR 0.15 m PIPE DIAMETER FOR A RANGE AT MANNING COEFFICIENTS FROM 0.009 to 0.018 .... A8.1
APPENDIX 9. JUMP LOCATION IN A 0.15 m DIAMETER PIPE AT 1/300 SLOPE CARRYING 6 l/s FOR A RANGE OF MANNING COEFFICIENTS A9.1
APPENDIX 10. SAMPLE OUTPUT, PROGRAM HYDJUMP A10.1
APPENDIX 11. PROGRAM HYDJUMP A11.1
APPENDIX 12. PROGRAM HYDSUM A12.1

LIST OF FIGURES

Page

Figure 1. Derivation of Chezy Equation for Steady Uniform Flow 22

Figure 2. Relationship Between Specific Energy and Flow Depth 23

Figure 3. Basis of Gradually Varied Flow Depth Profile Calculations 24

Figure 4. Schematic of Numerical Integration to Determine Water Surface Profile 25

Figure 5. Control Depths Employed in Water Surface Profile Integration 26

Figure 6. Forces Acting at Hydraulic Jump Location 27

Figure 7. Summary of Channel Cross Section Shape Calculations 28

Figure 8. Water Surface Profile and Associated (F&M) Profiles Used to Position Hydraulic Jump 29

Figure 9. Boundary Conditions Governing Jump Location 30

Figure 10. Boundary Conditions Employed to Indicate Jump Formation 31

Figure 11. Schematic Representation of Jump Boundary Conditions 32

Figure 12. Schematic Representation of Jump Position Identification Technique Employed 33

Figure 13. Variation of Normal and Critical Depth with Flow Rate and Pipe Slope 34

Figure 14. Variation of (F&M) Term with Flow Rate and Pipe Slope ... 35

Figure 15. Jump Location as a Function of Pipe Slope at 6 l/s Flow for a 0.15 Diameter Pipe 36

Figure 16. Jump Location in a Rectangular Channel, Width 0.15 m as a Function of Channel Slope 37

Figure 17. Variation of Jump Location with Flow Rate and Approach Pipe Slope, 0.15 m Diameter Channel 38

Figure 18. Variation of Jump Location with Flow Rate and Approach Pipe Slope, 0.15 m Width Channel 39

List of Figures (cont.)

Page

Figure 19. Pipe Diameter Effect at Q = 1 l/s 40

Figure 20. Channel Width Effect at Q = 1 l/s 41

Figure 21. Effect of Manning Coefficient on Jump Location. Note n Constant for Approach and Test Pipe 42

Figure 22. Effect of Manning Coefficient on Jump Location. Note n Constant in Approach Pipe at 0.015, Varied in Test Pipe 43

LIST OF TABLES

Page

Table 1. Summary of Hydraulic Jump Position Results for the 0.1 m Diameter Partially Filled Pipe with an Approach Pipe Slope of 45° 44

Table 2. Summary of Hydraulic Jump Position Results for the 0.1 m Width Channel with an Approach Channel Slope of 45° 45

Table 3. Schematic of Tabulated Jump Boundary Conditions 46

NOTATION

A	Channel cross sectional area
C	Chezy constant
D	Pipe diameter
E	Specific energy
$F\&M$	Sum of hydrostatic force, F, and momentum, M, at any flow section
F_r	Froude number
g	Acceleration due to gravity
h	Flow depth
$\overline{h}$	Centroid depth
h_c	Critical flow depth
h_n	Normal flow depth
L	Jump location distance from pipe entry
m	Hydraulic mean depth
n	Manning coefficient
P	Wetted perimeter
Q	Flow rate
S	Slope of energy grade line
S_o	Channel slope
T	Water surface width in channel
V	Local average velocity
W	Width rectangular channel
Z	Elevation channel above some datum
ρ	Fluid density
θ_1	Approach pipe slope
θ_2	Test pipe slope

1. INTRODUCTION

Early studies of the formation of a hydraulic jump in open channel fluid flow may be traced to the 1820's and to a large extent were responsible for the classification of flow regimes in open channels now employed. The major work on jump formation has been, historically, directed towards the large civil engineering excavated channels with near horizontal bed slopes and straight sided cross sectional shapes. Both experimental and analytical treatments find wide application in such open channel design. Characteristically the presence of a hydraulic jump is responsible for the necessary water surface profile discontinuity that must occur if flow is established in a channel at a velocity compatible with the rapid or supercritical flow regime when the channel slope and roughness characteristics dictate that subcritical, or tranquil, flow regime conditions should prevail. Obviously such a method of increasing flow depth also provides a potent energy dissipation and flow mixing mechanism. These characteristics of the hydraulic jump to some extent explain the interest in this phenomenon in open channel design. Chow [1] quotes a wide range of useful applications of the jump mechanism in open channel erosion and bed uplift by decreasing local velocity and increasing flow depth. Similarly the mixing properties of the jump can be utilized in chemical water purification processes as well as in aeration.

A review of the literature on the topic therefore reveals a strong bias toward large scale applications, with the design criteria being designed with a view to including rather than excluding the hydraulic jump from open channel flow.

In drainage design both scale and motivation are diametrically opposed to the situation described above. The conditions governing the formation of a hydraulic jump translate unchanged with the scale of the system; however in the design of a drainage system the occurrence of a jump is to be avoided if possible. In a partially filled drainage pipe the occurrence of a hydraulic jump could result in a local full bore flow that would interfere with the venting of the system and could lead to back pressure problems upstream. Vertical stacks discharging into shallow gradient drains represent a design condition that could lead to jump formation. Additionally the local full bore flow could deposit suspended material on the crown of the pipe, leading after sometime to a possibility of pipe restriction and blockage. The location of a jump in plumbing systems design is of secondary importance.

In the special case of hospital drainage flow in the UK this has been found to be a particular problem due to the use of the drainage system to transport macerated disposable bed pans manufactured from strengthened paper-mache.

Thus in drainage design the hydraulic jump is to be avoided where possible by design.

The objective of the computer simulation described in this report therefore was to produce a usable computer program that could give guidance on the design condition likely to produce a hydraulic jump. It was intended that the computer program would be tested in the work reported for a range of flow conditions and pipe sizes and slopes typical of drainage design. These values incidentally being far removed from the calculation examples found in the literature for channels carrying flows measured in MG/Day.

However, as mentioned, the basic prediction methods and the flow criteria translate across the scale differentials. One problem however does become obvious and that relates to channel cross section shape. The criteria relating to jump formation are primarily related to flow depth and velocity and hence, for a known flow rate, to channel cross section. Similarly the forces acting involve the calculation of flow centroidal depth. The large body of literature available is almost entirely restricted to simple, straight sided channel shapes, and understandably so. The introduction of circular sections, while not in itself difficult in a numerical computer aided solution, dispenses with any possibility of deriving analytical solutions for jump location, strength or depth change. Douglas et al. [2], for example present a jump location calculation technique for a simple rectangular channel, with a range of simplifying assumptions, that is typical of the analytical treatments available [3, 4].

The technique chosen for this study was based on the assumption of gradually varied flow conditions both upstream and downstream of the hydraulic jump formed in the channel as a result of the slope change. Gradually varied flow implies that the flow parameters change sufficiently slowed for the steady, uniform flow equations, characterized by Chezy and Manning, to be applied to incremental length sections employing the local depth and velocity values.

The criteria determining the formation of the jump are well documented in terms of a force and momentum balance at the jump between the upstream and downstream water surface profiles. This force and momentum balance leads to the concept of conjugate depths and hence to the strength and depth change associated with the jump. The gradually varied flow assumptions allow the water surface profiles to be calculated and hence the jump position may be calculated.

This report presents the theoretical background to a computer model based on the gradually varied flow assumption and the force and momentum equivalence criteria for jump formation. A listing of the Fortran programs written to model the problem is presented together with flow charts and data input descriptions that will allow future use of the developed techniques. Results for a range of flow and pipe and channel design parameters typical of drainage systems are included, both as summary tables produced by the programs and in graphical form to illustrate points and trends of particular interest.

2. THEORETICAL CONSIDERATIONS

2.1 Steady, Uniform Flow in Open Channels

Figure 1 illustrates the force balance equation for steady flow in an open channel or partially filled duct. The common expression of this relationship is known as the Chezy equation where

$$V = C \sqrt{mS_o} \tag{1}$$

m = hydraulic mean depth A/P, m
S_o = sin θ duct slope
V = mean velocity, m/s
C = Chezy constant.

The value of Chezy coefficient C was found by Manning to be dependent on hydraulic mean depth and duct surface roughness n. The Manning formula is the simplest of the open channel equations:

$$V = \frac{1}{n} m^{2/3} S_o^{1/2}$$

$$Q = \frac{1}{n} A\, m^{2/3} S_o^{1/2} \tag{2}$$

where Q is the flow rate, m^3/s
A is the flow cross sectional area, m^2

The value of the Manning coefficient, n, varies with pipe or channel material. Chow [1] suggests values in the range 0.009 to 0.018 for materials commonly found in building drainage systems.

Equation 2 determines the flow depth under steady, uniform conditions, only one value of h yielding the values of A and m necessary to satisfy the equation. As this depth is by definition constant downstream, $dh/dx = 0$, it must also be the terminal depth corresponding to the flow terminal velocity at that channel slope.

This depth, h_n, is commonly referred to as the normal depth.

The specific energy of the flow may be defined as

$$E = h + \frac{V^2}{2g} \tag{3}$$

where h = local flow depth, m
V = local average flow velocity, m/s

For non-uniform velocity distributions a kinetic energy coefficient weighting factor, α, may be introduced as $\alpha V^2/2g$; here, the assumption is made of uniform distribution with $\alpha = 1$.

It may be shown that for a rectangular channel, width W, that there are two possible depths for any particular value of E above a minimum.

$$E = h + \frac{V^2}{2g} = h + \frac{Q^2}{2gA^2}$$

A = hW for rectangular case

$$E = h + \frac{Q^2}{2g(hW)^2}$$

$$h^3 - Eh^2 + Q^2/2gW^2 = 0$$

For a constant specific energy, E, this equation has three roots; two real, one imaginary. Figure 2 illustrates the alternate depths possible for a constant specific energy, generally characterized as rapid and tranquil flow. It will be shown that the boundary between these two alternatives depends on flow rate and cross sectional shape.

From equation 3 and Figure 2 it may also be seen that the flow specific energy has a minimum value below which the given flow conditions cannot exist. In a channel of arbitrary cross sectional shape this value may be determined as follows:

$$E = h + \frac{Q^2}{2gA^2}$$

$$\frac{dE}{dh} = 0 = 1 - \frac{Q^2}{gA^3} \frac{da}{dh} \qquad (4)$$

From Figure 2

$$dA = T\ dh \qquad (5)$$

where T is the surface width at any depth, h.

From equations (4) and (5) the minimum value of E will occur at a depth value, h_c, that satisfies the expression

$$1 - Q^2T/gA^3 = 0 \tag{6}$$

This value of h is referred to as the flow critical depth h_c.

If the normal flow depth h_n exceeds h_c then the terminal flow would be termed subcritical, or tranquil flow. If h_n is less than h_c then the flow is termed rapid or supercritical.

It should be stressed that h_c is independent of pipe slope and pipe surface roughness; while the normal depth is dependent on both. Thus the same volume flow rate in any particular pipe may be rapid or tranquil depending on pipe slope, and similarly the same flow rate in a series of constant diameter pipes will be tranquil or rapid depending on roughness.

Pipes or channels in which rapid flow is normal are termed steep; pipes or channels in which tranquil flow is normal are termed of mild slope. It will be shown that hydraulic jumps may only be established in mild slope channels.

2.2 Gradually Varied Flow in Open Channels

Gradually varied flow is steady non-uniform flow of a special type. The flow parameters are assumed to change slowly, if at all, in the flow direction. The basic assumption in the treatment of this type of flow is that the local head loss at any section is given by the Manning expession, equation 2, for the local flow depth and rate under assumed steady, uniform flow conditions.

Based on the assumptions above and figure 3, the depth profile may be expressed as follows:

$$\frac{d}{dL}\left\{\frac{V^2}{2g} + (Z_o - S_oL) + h\right\} = -\left\{\frac{nQ}{Am^{2/3}}\right\}^2 \tag{7}$$

where $(Z_o - S_oL)$ is the elevation at distance L along the channel, measured in the downstream direction; S_o is sin θ, channel bed slope,

$$\text{hence } -\frac{V}{g}\frac{dv}{dL} + S_o - \frac{dh}{dL} = {\frac{nQ}{Am^{2/3}}}^{2} \tag{8}$$

and as, $Q = VA$

$$\frac{dV}{dL}A + V\frac{dA}{dL} = 0$$

and $\frac{dA}{dh} = T$ from equation 5 it follows that

$$\frac{dV}{dL} = -\frac{V}{A}\frac{dA}{dL} = -\frac{VT}{A}\frac{dh}{dL} = -\frac{QT}{A^2}\frac{dh}{dL}$$

and substituting in equation (8) yields

$$\frac{Q^2T}{gA^3}\frac{dh}{dL} + S_o - \frac{dh}{dL} = \left\{\frac{n\ Q}{A\ m^{2/3}}\right\}^2 \tag{9}$$

$$dL = \left\{\frac{1 - Q^2T/g\ A^3}{S_o - (nQ/Am^{2/3})^2}\right\} dh$$

$$L = \int_{h_o}^{h_1} \frac{1 - Q^2T/gA^3}{S_o - (nQ/Am^{2/3})^2}\, dh \tag{10}$$

where L is the distance between two known depths h_o, h_1.

Figure 4 illustrates this numerical integration, which may be conveniently achieved by Simpson's rule.

The numerator and denominator of the function to be integrated in equation 10 may be recognized as the equations determining the critical and normal flow depths in an open channel.

When the term $(1 - Q^2T/gA^3)$ is zero the flow is at critical depth, i.e., there is no change in L for a change in h.

When the term $S_o - (nQ/Am^{2/3})^2$ is zero uniform flow depth is achieved, i.e., there is no change in h for a change in L.

For uniform cross section channels with constant roughness, n, and slope, S_o, the expression (10) becomes solely a function of flow depth h.

In order to numerically evaluate (10) it is necessary to define boundary conditions from which the integration may proceed. It should be stressed that the integration may be carried out either upstream or downstream from a known depth point. This ability is central to the use of this technique to determine the position of a profile discontinuity, such as an hydraulic jump.

Figure 5 illustrates the control depths used in the prediction of the water surface profiles in the case being investigated, namely the change in slope of an open channel.

It is assumed in figure 5 that suitable conditions exist for the formation of a hydraulic jump in the pipe downstream of the slope change. In order to predict the water surface profiles therefore three control depths are required as follows:

1) Downstream boundary at C. It may be assumed that the downstream boundary is formed by the condition that critical flow depth forms at a free discharge. Experimental work (3) has shown that the depth at such a discharge is slightly less than critical and that the critical depth occurs slightly upstream, around 0.7 pipe diameters, however this assumption is sufficient if the channel considered is long.

   Naturally if the normal flow depth is less than critical then the flow depth is unaffected by the presence of the discharge point and normal depth is maintained up to the exit at C. In this condition the flow is termed supercritical and the local wave speed is less than the flow velocity. For this reason information concerning the presence of the open discharge cannot be transmitted upstream, hence the maintenance of normal depth.

   Calculation of the water surface profile upstream from C show that normal flow depth is approached very rapidly, perhaps within 10-15 pipe diameters. For this reason a simplification that is considered justified would be to assume normal flow depth, above critical, in the whole pipe section B to C. This simplification has a bearing on the calculated position of the hydraulic jump as will be discussed later.

2) The upstream boundary at B. The upstream boundary is dependent on the exit conditions from the steep pipe AB, figure 5. If the specific energy at B in pipe AB is known, together with the flow rate, Q, then it is possible to predict the depth at B in pipe BC. Alternatively the flow rate and specific energy at B could be used as input information to the calculation, dispensing with the pipe length AB water profile integration.

3) The entry condition at A. The entry condition at A determines the flow profile in AB. Critical depth at the entry point A may be used, the normal depth in the steep pipe AB will be less than this value and the profile will take on the shape shown in figure 5, approaching normal depth at some point along AB.

   Alternatively the pipe length AB may be assumed long enough for terminal flow conditions to be achieved at B. This despenses with the calculation of the water surface profile in AB as equation (2) may be used to determine normal supercritical depth at B and equation (3) determines the appropriate specific energy provided the channel depth-area relationship is known.

   The choice of the depth increment value dh in the numerical integration is based, in this treatment, on the difference between the control depth for that section and the "target" depth. For example in section C to B the control depth is the critical depth at C while the target is the normal flow depth reached at some point between C and B. The depth cannot exceed this target. Hence an appropriate increment site may be calculated by

$$dh = (h_n - h_c)/N, \text{ C to B} \tag{11}$$

where N is some reasonable number in the range 10 to 30, depending on the desired accuracy and computation time.

Similarly for the section B to C

$$dh = (h_c - h_B)/N \tag{12}$$

For the steep slope A to B the increment would be

$$dh = (h_A - h_B)/N \tag{13}$$

where h_B is the normal depth expected for that particular channel and flow conditions.

2.3 Hydraulic Jump

The hydraulic jump is an important example of local nonuniform flow. In drainage design it is to be avoided as the local depth increase may be sufficient to produce full bore flow and associated back pressure problems. However, in the wider engineering context the inclusion of a hydraulic jump is often beneficial as a means of rapidly dissipating flow energy, with consequent reduction in channel erosion problems, the design of power plant turbine tail races being an example.

There is a considerable body of experimental and analytical literature available on the formation and characteristics of the hydraulic jump. The majority of this work is related directly to large civil engineering applications and is also confined to channels of straight sided cross sectional shape, from rectangular to trapezoidal. This is understandable as such channel shapes would be the naturally excavated design. Although laboratory models usually employ rectangular glass sided open channels to study, for example, jump formation downstream of a sluice gate, no references were found to the case of jump formation downstream of a slope change in small diameter partially filled pipes, namely the building drainage case.

The flow process leading to the formation of a hydraulic jump may be explained as follows: Assume that flow is established in a mild slope channel at a depth below critical for that channel and flow rate. As the normal flow depth is greater than critical, i.e., definition of mild slope, the effect of cumulative friction losses in the channel will be to increase the depth, with a consequent decrease in local average velocity. This depth change should continue until normal flow depth is achieved at some downstream point. This cannot happen via a gradually varied flow process as the theoretical water surface slope would have to be vertical as the depth passed through the critical value. Hence a discontinuity, or jump, in the depth profile is required to transfer the flow from supercritical conditions upstream of the jump to subcritical downstream. It is important to note therefore that such a discontinuity can only occur from a depth below critical to a depth above critical.

In the steady flow case, namely flow conditions constant with time, the position of this jump may be determined by a consideration of the forces acting on the fluid at the jump position and the water surface profiles upstream and downstream of the jump, figure 6.

Referring to figure 6 and assuming both a near horizontal channel, so that the fluid weight component may be ignored, and steady flow conditions, application of the momentum equation yields:

$$F_{h1} - F_{h2} = \rho\ Q(V_2 - V_1)$$

where F_h are the hydrostatic forces at 1 and 2

hence $\rho_g A_1 \bar{h}_1 - \rho_g A_2 \bar{h}_2 = \rho A_2 V_2^2 - \rho A_1 V_1^2$ (14)

where A is the flow cross sectional area and h is the centroid depth, as illustrated in figure 7.

Rearranging (14) yields:

$$(\rho g A\bar{h} + \rho_g A\bar{h} + \rho A V^2)_2$$

or

$$(F+M)_1 = (F+M)_2 \qquad (15)$$

where M is the momentum term ρAV^2

This analysis assumes that the jump length may be ignored, this allows the exclusion of local frictional effects over the pipe section containing the jump. This point will be returned to in the discussion of the prediction model.

It will be seen that both F and M depend on the flow depth and on the relationship between depth and area and hence centroid position.

The complexity of this expression (15) depends entirely therefore on the form of the depth to area relationship and on the local water surface profiles either side of the jump. The (F+M) term is sometimes referred to as the specific force (1); however this not entirely satisfactory due to the momentum content, and thereafter it is referred to as the (F & M) term.

Thus the position of the jump may be predicted provided that the flow depth profiles upstream and downstream are known. A knowledge of local depth plus the steady flow assumption allows all the terms in equation (15) to be calculated and allows the (F & M) values applicable to each point on either water surface profiles upstream and downstream of the jump to be plotted as shown in figure 8.

The intersection of the two (F & M) curves fixes the jump position. The two corresponding depths on the upstream and downstream water surface profiles are the conjugate depths for the jump and allow the energy loss to be calculated across the jump.

$$\Delta E = \{h + \frac{V^2}{2g}\}_2 - \{h + \frac{V^2}{2g}\}_1 \tag{16}$$

The formation of a hydraulic jump downstream of a slope change is not inevitable however. Figure 9 illustrates five conditions that should be considered in evaluating the possibility of jump formation.

a) If the flow normal depth, dependent on both pipe slope and roughness, is less than the critical depth, that is independent of slope or roughness, then no jump will form.

b) If the flow normal depth is greater than the critical depth and the (F & M) term at pipe entry is greater than the normal depth (F & M) value, then a jump will form as shown in figure 9. Its position may be determined as described previously.

c) If the pipe is insufficiently large in cross sectional area to maintain a free water surface, i.e., open channel flow, then full bore flow will be established in the pipe. This case is not treated here beyond its identification by comparing the normal depth calculated to the available pipe diameter.

d) A more interesting case occurs if the (F & M) value at pipe entry, i.e., at the slope change, is less than the (F & M) value appropriate to the downstream normal flow depth. In this case the jump effectively forms in the steep pipe, or it may be regarded as drowned at pipe entry. Analysis of this case requires the introduction of the mass component down the steep slope appropriate to the water mass contained between the sections 1 and 2 in figure 6. This introduces the physical length of the jump, obviously a simple treatment regards the jump as concentrated in one location; however in practice it can have lengths several times its downstream depth. Chow [1] presents an analysis based on empirical jump length measurements for rectangular channels, however no data is available for partially filled pipes and for the purposes of this study this case is merely identified by a comparison of the (F & M) term values as mentioned above.

e) A trivial case is formed when the length of pipe available downstream of the slope change is short. Here no jump will form if the length is less than that necessary for the flow depth to increase to the theoretical jump conjugate depth value appropriate to the upstream water surface profile. This case is not illustrated in figure 9.

Figure 10 illustrates the tests associated with these boundary conditions. It will be seen that (F & M) curve vs. slope has a minimum value, hence for particular pairs of values of θ_1, and θ_2 the (F & M) terms may change in their relative magnitudes.

Figure 11 summarizes these tests into a format that will be employed later in the generation of tables to indicate jump formation possibility.

2.4 Loss Coefficients for Slope Transitions in Open Channel Flow

No data could be obtained on the loss coefficients for slope transitions in open channel flow. For this reason the results presented assume no loss at the test pipe entry. The computer program as written has been designed to include such a loss coefficient, in the range 0 to 1, should such data become available from a future experimental program. The effect of such a loss would be to increase the flow depth at pipe entry, with a consequent decrease in the (F & M) term at pipe entry. In turn this would have the effect of generally moving the jump location upstream towards pipe entry. At the lower approach pipe slopes this effect could result in the jump appearing to become drowned at pipe entry. Experimental work is required to verify the model and the predicted effects of the loss coefficient discussed above.

3. CALCULATION TECHNIQUES AND PRESENTATION OF RESULTS

3.1 Determination of Normal and Critical Depths

The bisection method was used to solve the equation defining both critical flow depth

$$X = 1 - Q^2T/gA^3$$

and normal flow depth

$$Y = S_o - (n\ Q/Am^{2/3})^2$$

It may be assumed that both X and Y have zero values for some value of depth h in the range $0 < h < D$ for pipe case or $0 < h < W$ for the square section case. The process is described below:

The initial interval is bisected and a trial value of $h = D/2$ or $W/2$, depending on geometry, is used to evaluate X, Y above. If the resulting values are positive then the sought after root is less than the trial value just used.

A new trial value is obtained by bisecting the interval 0 to D/2 or W/2 and X and Y recalculated. If the values obtained remain positive, a further reduction in trial value is obtained by bisection.

If the values of X, Y are negative then the desired root is larger than the trial value and an increased h value is obtained by bisection between the upper limit, in this case D or W, and the trial value just employed. This process may be repeated until the required root is obtained.

Due to the need to include the area depth relationship the solution process must be iterative. The computation time depends largely on the complexity of the area-depth function.

3.2 Numerical Integration for Surface Profiles

The integration of the position vs depth profile

$$L = \int_{h_1}^{h_2} \frac{1 - QT^2/gA^3}{S_o - (nQ/Am^{2/3})^2}\, dh$$

is achieved by means of Simpson's Rule. Let the integral $X = \int_{h_0}^{h_1} F(h)\, dh$, then if the interval h_1-h_0 is divided into 2 equal increments, the value of X is given by

$$X = \frac{1}{3} dh \; [(F(h_o) + 4F(h_o+dh) + F(h_o+2dh)]$$

As the integration moves on the length traversed may be accumulated as L = L + X at the completion of each integration.

3.3 Determination of Jump Position

The water surface profiles and the associated (F & M) curves for the flow upstream and downstream of the jump are illustrated by figure 8. The jump position is determined in the following manner within the computer program; figure 12 illustrates:

1) Choose a small increment Δx less than the smallest ΔL on either of the water surface profiles. Note ΔL varies along each profile as shown in figure 4.

2) For the water surface profile downstream of the jump, i.e. that calculated by integration back from the critical depth at pipe discharge, determine the calculated profile points on either side of the Δx value, measured from pipe entry, points G, H figure 12.

3) Calculate the (F & M) value at position Δx on the downstream profile, point J.

4) For the profile calculated by integration downstream from pipe entry determine whether the corresponding (F & M) values at the known profile points on either side of Δx are bracketing the trial (F & M) value from step 3, points K, M. If this is the case the curves intersect in this increment, if both are greater than the trial value then the curves have not intersected up to this interval.

5) If the curves have not intersected, increase the search position from x to x + Δx and repeat steps 2 through 4.

6) If the curves have intersected then the intersection point can be obtained by solving the two straight line equations representing the water surface profiles between the two pairs of known points bracketing the intersection position. This is illustrated by points UV, and XY in figure 12.

   The technique uses the simplifying assumption that the water depth downstream of the jump is at the normal flow level, hence (F & M) for C to B becomes a known constant. This simplification was extensively used in the results presented (in figure 12 the resulting downstream depth was H then became the constant normal depth value).

3.4 Presentation of Results

The parameters governing the flow and the location of the hydraulic jump are numerous. The selected test cases, analyzed by program HYDJUMP run on the NBS CBT Perkin Elmer 732 computer, are summarized below:

1.1) Pipe diameters: 0.075, 0.10, 0.15 m.
1.2) Manning coefficient 0.015.
1.3) Test pipe slopes at all pipe diameters: 1/40, 1/80, 1/100, 1/200 (Additionally slopes 1/150, 1/300, 1/400, 1/600 were run for the 0.15 m diameter pipe only).
1.4) Approach pipe slopes 2°, 4°, 6°, 10°, 20°, 30°, 45°, 60°, 75° and 90°.
1.5) Additionally for the 0.15 m pipe at 1/300 slope, the effect of Manning coefficient values of 0.009, 0.012, 0.015 and 0.018 on jump position for the whole range of approach slopes was carried out at one flow rate.

2.1) Rectangular channels, width 0.075, 0.10, 0.15 m.
2.2) Manning coefficient 0.015 only.
2.3) Test pipe slopes 1/40, 1/80, 1/100, 1/200.
2.4) Approach pipe slopes 2°, 4°, 6°, 10°, 20°, 30°, 45°, 60°, 75° and 90°.

The full results are presented in tabular form in a series of appendices.

In addition plotted data is presented to illustrate the main points in the discussion of the results.

The results indicated the need to determine the boundary conditions in terms of normal and critical flow depths, pipe diameter and (F & M) values. This led to an additional program HYDSUM, capable of calculating normal and critical depths as well as (F & M) values. Tables based on this program's output are included as a method of determining whether a jump will form in the test pipe.

The two main programs, HYDJUMP and HYDSUM are included in an appendix together with flow charts and input data instructions.

3.5 Selection of Input Data

The choice of input test conditions was governed by the range of values likely to be found in drainage systems. The pipe diameters chosen, 0.075, 0.10 and 0.15 conform to this criteria as do the pipe gradients used for all test cases, 1/40, 1/80, 1/100, 1/200. The choice of pipe roughness or Manning coefficient was more difficult, however values in the range 0.009 to 0.018 are recommended in many texts, i.e. Jaeger [3] and Chow [1].

As previously discussed, the losses at the change of slope that produce the conditions conducive to hydraulic jump formation have been ignored in this treatment. No available data on open channel transition loss coefficients for partially filled pipes or channels could be obtained. The program is capable of dealing with transition losses however via an input data control variable provided the loss can be expressed as a factor, 0 to 1.0, of the specific energy of the flow at pipe entry.

4. DISCUSSION

The position of the hydraulic jump in a mild slope channel following a change in bed slope is determined by the equivalence of the hydrostatic force plus momentum terms outlined in equations 14 and 15 and figures 6 and 8. If, as a starting assumption, the flow downstream of the jump is assumed to be uniform and at normal depth, then the jump position appears to be entirely dependent on the rate of change of the (F & M) term with respect to distance along the channel. This is demonstrated in figure 12, and the following analysis.

The results for jump location therefore may be discussed in terms of the parameters governing this gradient, d(F & M)/dL.

From equation 14, that the (F & M) term at any location may be expressed as

$$(F \,\&\, M) = \rho g A\bar{h} + \rho A V^2$$

$$F \,\&\, M = \rho g A\bar{h} + \rho \frac{Q^2}{A} \qquad (17)$$

$$\frac{d(F \,\&\, M)}{dL} = \rho g A \frac{d\bar{h}}{dL} + \rho g h \frac{dA}{dL} - \rho \frac{Q^2}{A^2}\frac{dA}{dL} \qquad (18)$$

The form of equation (17) indicates that (F & M) will initially decrease as depth and hence area A increase, however at some depth value the hydrostatic force term will predominate and the (F & M) value will increase. It therefore follows that there would theoretically be two intersection points for the two (F & M) curves in figure 12, however the intersection closest to the pipe entry is the valid solution and the technique described in figure 12 will ensure that this is the solution produced. The form of equation (18) confirms this point, d(F & M)/dL being initially negative due to the predominance of the momentum term.

As the rate of decrease of (F & M) is dependent on both depth and rate of change of depth, it is necessary to incorporate the Manning equation to represent local friction losses at the equivalent steady, uniform flow conditions. This appears in the denominator of equation (10) and may be used to explain the movement of the jump position.

$$\frac{\Delta h}{\Delta L} = \frac{S_o - (n\,Q/Am^{2/3})^2}{1 - Q^2T/gA^3} \qquad (19)$$

Changes in S_o, Q, and n that result in an increase in the value of $\Delta h/\Delta L$ will indicate an increase in d(F & M)/dL, however this does not automatically imply that the jump position will move upstream.

Figures 13 and 14 illustrate the dependence of flow normal and critical depths and (F & M) values on flow rate and pipe slope for the 0.15 m diameter pipe case. It will be seen that as Q increases or S_o decreases, the values of normal depth and (F & M) increase. This effectively reduces the necessary drop from the (F & M) value associated with the water surface profile at pipe entry upstream of the jump, figure 12, and would imply, for a constant d(F & M)/dL, a jump location movement towards pipe entry.

Consider the jump location movement illustrated in figure 15. For constant Q, D, n and test pipe slope, $S_o = \sin \theta_2$, the value of $\Delta h/\Delta L$ will be constant, equation (19). Similarly for constant Q, D, n and S_o the value of normal depth in the test pipe, figure 13, will also be constant, providing a constant target (F & M) value.

However as the approach pipe slope, θ_1, increases the value of the entry conditions to the test pipe change, the entry depth decreases and the entry velocity rises. Thus as θ_1 increases the entry value of (F & M) at L=0 increases, this effect for constant flow rate is illustrated in figure 14.

Therefore the intersection point between the (F & M) curves associated with the water surface profiles upstream and downstream of the jump would be expected to move downstream as the approach pipe slope increased. This effect is illustrated in figure 15 for each of the test pipe slopes considered. Figure 16 confirms this result for the rectangular section channel.

Inherent in the definition of the hydraulic jump location is the criterion that the depth upstream of the jump is below critical and that downstream is above critical. This implies that the Froude Number (upstream of the jump), defined as

$$F_r = V/\sqrt{gh} \tag{20}$$

is greater than unity upstream and less than unity downstream. This results in the inability of jump position information to be transmitted upstream as the wave speed is less than the local flow velocity. As a result of this the depth downstream of the jump may be thought of as the sole determinant of jump position for similar flow situations. This effect is illustrated in figure 15 and 16.

Consider the case of constant approach pipe slope θ_1 and constant flow rate Q, i.e. vertical lines drawn in the L - sin θ_1 plane. In this situation the (F & M) value at pipe inlet remains constant, however as the test pipe slope, θ_2 decreases the normal flow depth increases and with it the target (F & M) value, figures 13 and 14. Thus the downstream flow depth controls the jump position, the jump moving towards the pipe inlet as the test pipe becomes less steep. Jaeger [3] quotes this depth effect as the sole determinant of jump position in the case of hydraulic jump formation upstream of an obstruction to the flow.

As indicated in figure 15 jump location may be expressed by an equation of the form

$$L = L_x - C^K \sin(\theta-\theta_o)^{0.25} \tag{21}$$

It was felt that such an empirical formula had little value in this situation due to the complexity of the boundary conditions already described and the ability of the computer simulation to predict jump positions for a wide range of flow conditions in a relatively short time. It would appear from the available literature, although primarily directed to large civil engineering applications, that this conclusion is shared by most investigators, as no similar relationship was found. In every case it was recommended that jump position be calculated by the gradually varied flow analysis presented for each set of flow conditions.

The downstream depth also controls jump position as indicated by the results presented in figures 17 and 18. Here for constant $S_o = \sin \theta_1 = 1/200$ and constant D and n the jump location moves upstream as the flow rate decreases from 8 to 1 ℓ/s. Reference to figure 14 at any value of sin θ_1 indicates that the differential between (F & M) at L = 0, i.e. pipe entry value, and the (F & M) value appropriate to normal depth in the test pipe, decreases as the flow rate decreases. Hence, with reference to figure 12, the intersection position would be expected to move upstream, as confirmed for both circular and rectangular cross section channels by figures 17 and 18.

It will be noted that none of the jump position curves pass through the origin. This is to be expected as theoretically the jump location would tend to L = 0 as approach pipe slope θ_1 approaches the test pipe slope θ_2. In addition to this effect some of the curves, namely those representing shallow test pipe slopes, intersect the sin θ_1 axis at approach pipe slopes greater than this minimum. This is due to the drowning of the jumps at pipe entry, as illustrated in figure 9, Case 4, caused by a reversal of the differential between (F & M) at pipe entry and the (F & M) value associated with the normal depth flow in the test pipe. As mentioned previously the jump moves upstream into the approach pipe and a calculation of its position requires a knowledge of jump length and approach pipe slope. No theoretical calculation technique for jump length, i.e. the distance between control sections 1 and 2 in figure 6, is available, the data on this variable being entirely empirical and generally applicable only to straight sided channel shapes.

Tabulated results for the full range of test cases represented by figure 15 to 18 for pipe diameters and channel widths 0.075 to 0.15 m are presented in Appendices 1 to 6. Tables 1 and 2 present typical examples for the 0.1 m diameter pipe and channel cases. These results for the smaller dimensioned channels, 0.075 and 0.10 m diameter and width confirm the discussion presented above. Figures 19 and 20 are representative of these results.

Referring to figures 19 and 20, it will be seen that considerable difficulty was experienced in producing comparable test cases for the three channel dimensions chosen. This is entirely due to the influence of the boundary conditions introduced in figures 9 to 11. Indeed no jump formation was possible at 1/40 for the full range of test cases dealt with. This result prompted the preparation of tabular data based on the boundary conditions illustrated in figure 10 that would allow the formation of a jump, but not its location, to be predicted at considerably less computing time.

Table 3 illustrates the technique. Full tables for the test cases covered are presented in Appendix 7 and 8.

Referring to table 3, assume that the flow rate is Q_2, approach pipe slope is U_1 and test pipe slope is S_2. Pipe diameter is D and the Manning coefficient is n. The table has been produced by means of equations (2), (6) and (14) and allows the following boundary checks to be made, corresponding to figure 9.

1) Case 1, compare $hn_{1,2}$ to hc_2, if $hn_{1,2} < hc_2$, no jump possible.

2) Case 2, compare $hn_{1,2}$ to hc_2, if $hn_{1,2} > hc_2$, jump possible.

3) Case 3, compare $hn_{1,2}$ to D if $hn_{1,2} = D$, full bore flow, jump forms but location not determined.

4) Case 4, compare the normal flow depth value of (F & M) at Q_2 and S_1 in the test pipe, $(F \& M)_{12}$, to the value of the $(F \& M)^*$ term at pipe entry. It is assumed that this is equal to the terminal $(F \& M)^*$ value in the approach pipe and that the approach pipe was sufficiently long to allow normal flow depth to be established. Approach pipe slope designated U_1.

hence (i) if $(F \& M)_{12} < (F \& M)^*_{12}$, jump possible

(ii) if $(F \& M)_{12} > (F \& M)^*_{12}$, then the jump forms in the approach pipe or is drowned at pipe entry.

Appendix 8 presents similar tables for the 0.15 diameter test pipe case only for a range of Manning coefficient values 0.009 to 0.018. This table was used to determine a suitable test case for an evaluation of the effect of Manning coefficient on the jump location in a 0.15 m diameter channel. From Appendix 8 employing the method outlined above for table 3, a test case based in 6 l/s flow rate at a pipe slope of 1/300 was seen to produce a hydraulic jump at each of the values of Manning coefficient between 0.009 and 0.018 chosen. Appendix 9 contains the results of this test series while figures 21 and 22 summarize the data.

Two test cases were investigated.

1) Manning coefficient constant for both approach pipe and test pipe.

Figure 21 illustrates this case. As is to be expected the jump location moves downstream as the value of Manning coefficient decreases. This is in line with Jaeger [3] comments on the importance of downstream depth as the normal flow depth will decrease with decreasing Manning coefficient.

Similarly this result agrees with the description of jump location movement based on (F & M) values. As n decreases the normal flow depth (F & M) value in the test pipe decreases. For the approach pipe the decreasing n also results in a reduced normal depth, however due to the slope of the (F & M) vs slope curve illustrated by figure 10, this results in an increased value of (F & M) at test pipe entry. This increase in the differential between the entry and target (F & M) values in the test pipe effectively impose a downstream movement on to the intersection point and jump location, figure 12.

2) The Manning coefficient held constant at 0.015 for the approach pipe and only varied for the test pipe.

   The general trend in these results is similar to that described above. The constant value of n = 0.015 for the approach pipe effectively decreases the entry (F & M) value for the n = 0.009 and n = 0.012 cases, comparing figures 21 and 22. Hence the jump position would be expected to move upstream, as is demonstrated by the results. For the n = 0.018 case, the approach pipe effectively has a reduced n value and hence the terminal (F & M) value is increased and the jump position should move downstream. Again the results confirm this.

All the results discussed above were obtained with the assumption that terminal conditions had been achieved in the approach pipe and that the flow downstream of the jump could be considered uniform, i.e., the depth was equal to the normal flow depth defined previously. This assumption was necessary if any order was to be found in the results produced by the computer program. The program however was capable of producing jump location for any combination of pipe lengths, slopes and roughness coefficients.

Appendix 10 presents the full program output for a given set of pipe lengths and slopes. This output may also be used to justify the normal flow depth assumption downstream of the jump, as 95 percent of normal depth is achieved in some 20 pipe diameters. The output also presents the water surface profiles in the approach pipe and upstream of the jump in the test pipe.

Appendix 11 contains the full print out of the program HYDJUMP employed to generate these results and the control data necessary to vary the format of the data output and control the assumptions made in the calculations.

Similarly Appendix 12 presents the program HYDSUM employed to produce the tabular guides to jump formation summarized in table 1.

5. CONCLUSIONS AND FURTHER WORK

The objective of this study was the development and testing of a computer program capable of predicting the location of a hydraulic jump following a change in slope in an open channel or partially filled pipe.

The program HYDJUMP presented has been shown to be capable of jump prediction based on the assumptions inherent in the application of gradually varied flow analysis.

An extensive range of program test conditions were considered within the limits set by parameter values encountered in building drainage system design.

It was found possible to explain the movement of jump location with such parameters as flow rate, pipe slope, and roughness in terms of the criteria determining jump formation in near horizontal channels.

Although a considerable body of literature exists on hydraulic jump formation in civil engineering style open channels, no comparable study was found employing the parameter values presented. Similarly the majority of the available literature referred to straight sided open channels rather than to partially filled pipes of small diameter. All analytical solutions were restricted to the simplest rectangular section channels due to the complexity introduced by the depth to area and centroid position funcitons in non-rectangular sections.

The computer program, as included, has been designed to deal with rectangular or circular section channels. Extension to other shapes requires only that the shape functions be introduced into the two main subroutines, BOUND and CALC, and that the range of control values assigned to the control variable SHAPE be extended accordingly.

It is felt that the next stage in this study should be an experimental phase designed to compare the predictions from HYDJUMP with laboratory observations, incorporating modified assumptions where necessary. The loss at the pipe slope change, although incorporated in the program for future use, has not been investigated as to do so without laboratory test backing would be of little value.

As a result of the computer study, several boundary conditions that govern the formation of a jump were identified. As an aid to future work these boundary conditions were incorporated into a program HYDSUM, also presented, that enables the probability of jump formation to be assumed prior to running the more time consuming HYDJUMP to determine its location. The predictions of HYDSUM could also be used in designing a laboratory test series.

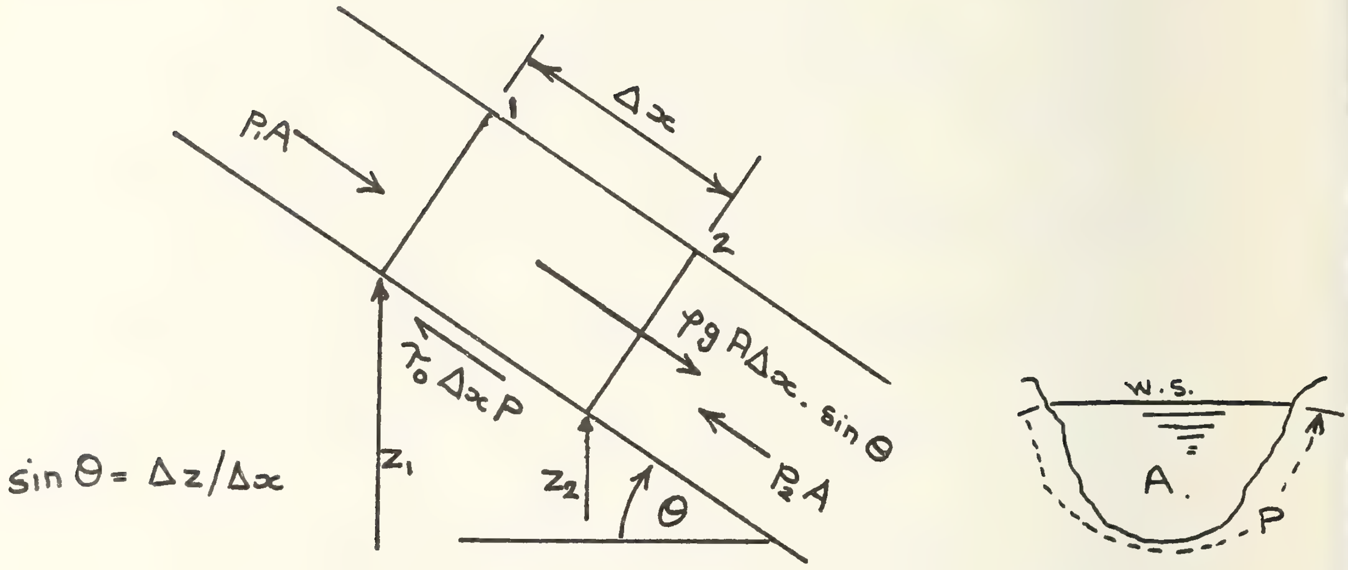
6. REFERENCES

[1] Chow, V.T., Open Channel Hydraulics, McGraw Hill, 1970.

[2] Douglas, J.F, Gasiorek, J.M. and Swaffield, J.A., Fluid Mechanics, Pitman 1979.

[3] Jaeger, C., Engineering Fluid Mechanics, Blackie and Sons, London, 1956.

[4] Streeter, V.L. and Wylie, E.B., Fluid Mechanics, McGraw Hill, 1974.



P_1A
1
Δx
2
$\rho g A\Delta x \cdot \sin\theta$
$\tau_0 \Delta x P$
P_2A
z_1
z_2
θ
$\sin\theta = \Delta z/\Delta x$
W.S.
A
P

At stations 1 and 2 the following equations apply:

Energy equation

$$\text{Losses} = h_f = \frac{p_1 - p_2}{\rho g} + z_1 - z_2$$

as $V_1 = V_2$; steady, uniform flow.

Momentum equation (down slope direction)

$$(p_1 - p_2)A + \rho g A\Delta x \sin\theta - \tau_o \Delta x P = 0$$

as $dV/dt = 0$; steady flow.

$$\therefore \frac{p_1 - p_2}{\rho g} + \Delta z = \tau o \frac{\Delta x P}{\rho g A} = h_f$$

For turbulent flow $\tau o = f \frac{1}{2} \rho v^2$

$$h_f = f \frac{\Delta x V^2}{2gm}, \quad V = C\sqrt{mS_o}, \quad \begin{aligned} S_o &= \sin\theta \\ m &= A/p \\ C &= \text{constant} \end{aligned}$$

Figure 1. Derivation of Chezy equation for steady uniform flow. Note no shape restriction on channel.

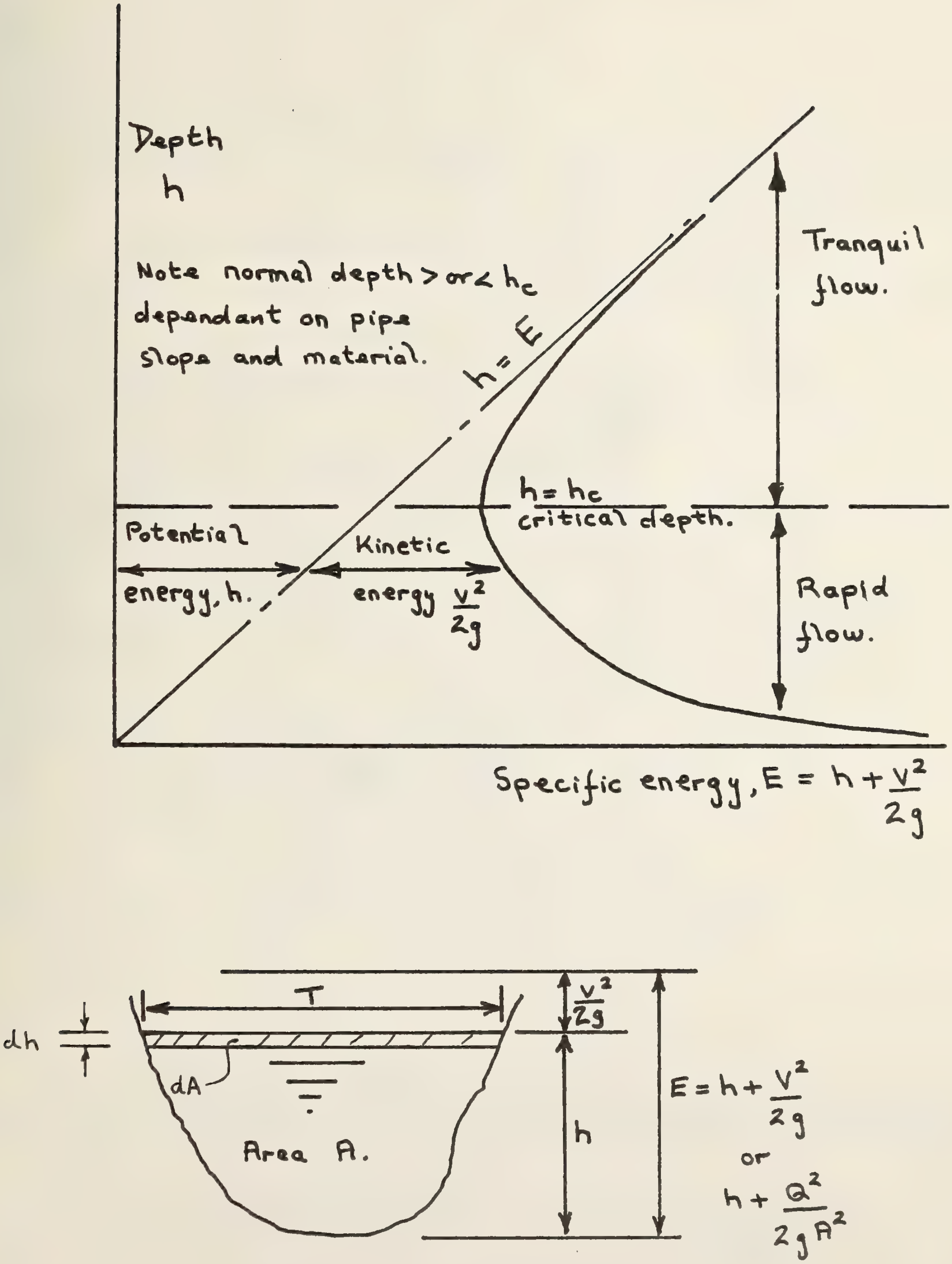
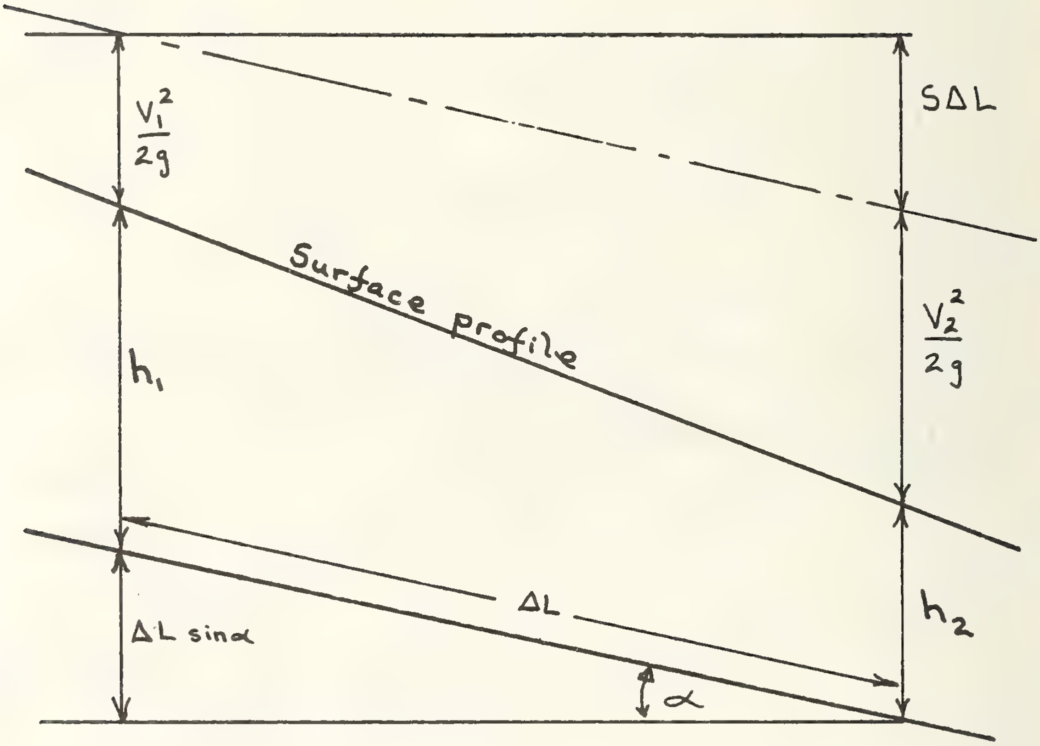


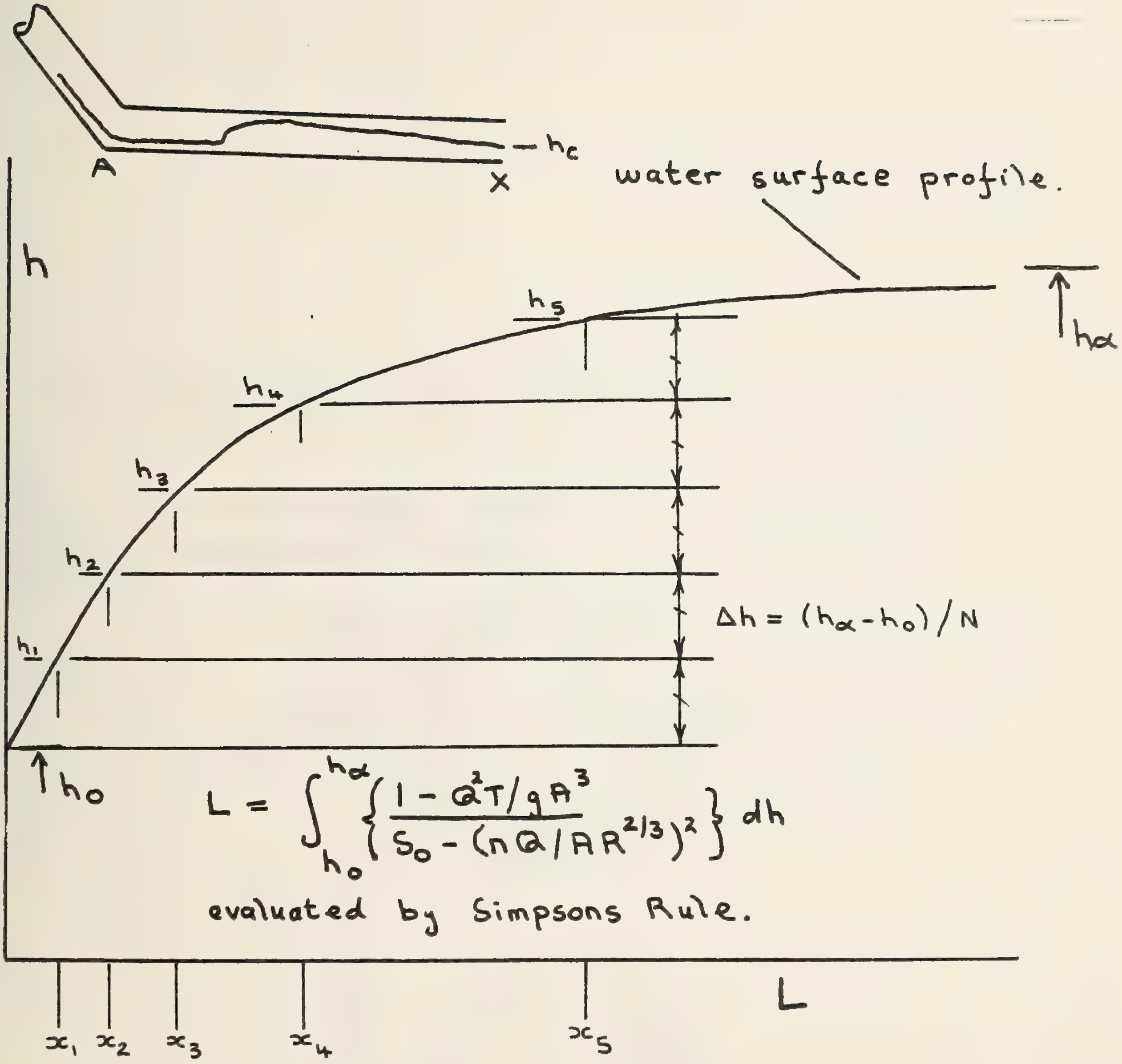
Figure 2. Relationship between specific energy and flow depth, illustrating alternate rapid or tranquil flow regimes.



Gradually varied flow, analysis based on head loss at any section being equal to Manning loss prediction, where

$$S = -\frac{\Delta E}{\Delta L} = \left(\frac{nQ}{Am^{2/3}}\right)^2$$

Figure 3. Representation of the gradually varied flow depth profile model.


h_c
A
X
water surface profile.
h
h_5
h_α
h_4
h_3
h_2
h_1
$\Delta h = (h_\alpha - h_o)/N$
h_o
$L = \int_{h_o}^{h_\alpha} \left\{ \frac{1 - Q^2T/gA^3}{S_o - (nQ/AR^{2/3})^2} \right\} dh$
evaluated by Simpsons Rule.
L
x_1
x_2
x_3
x_4
x_5

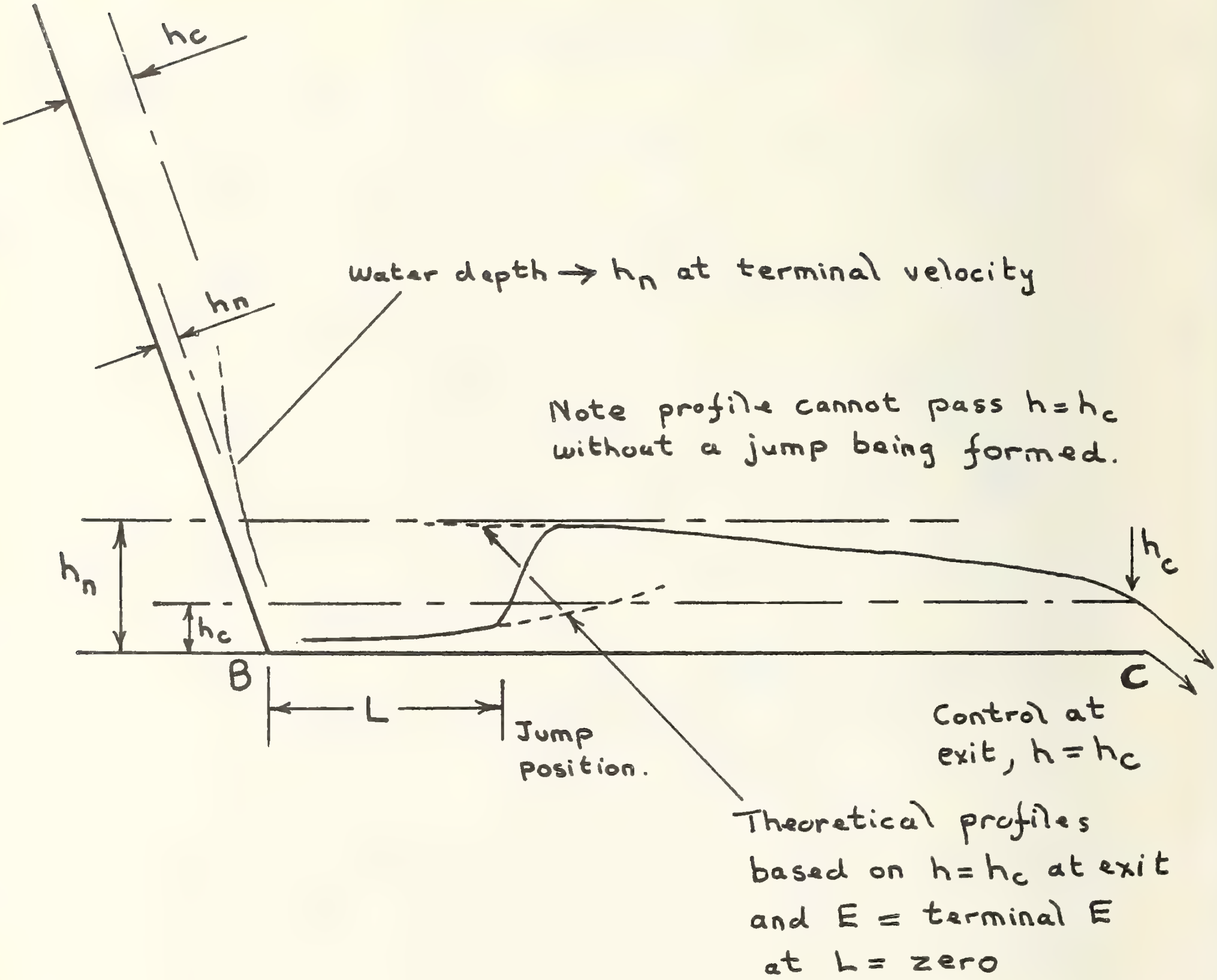
Note 1. ΔL increases as calculation proceeds

2. Calculation proceeds downstream from A to give profile $h_o \leq h < h_c$; h at A taken as intitial condition.

3. Calculation proceeds upstream from X to give profile $h_c \leq h < h_n$; h at X taken equal to critical depth as initial condition.

4. Value of N dependent on situation, range 10-30.

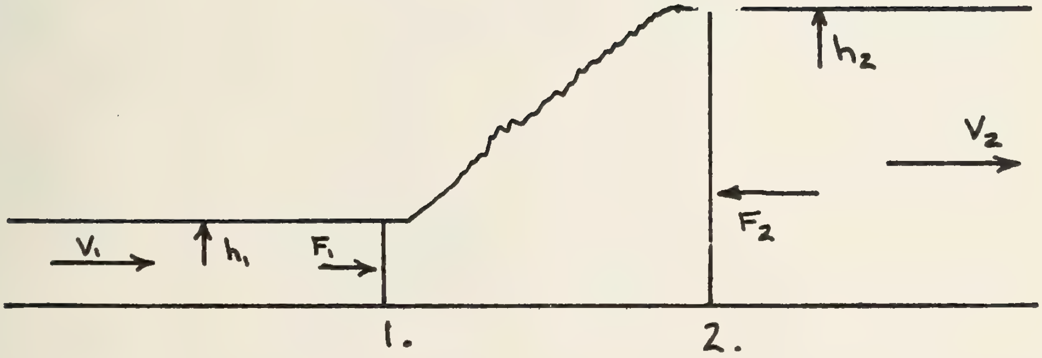
Figure 4. Schematic representation of numerical integration to determine water surface profile.



hc
hn
water depth → h_n at terminal velocity
Note profile cannot pass h = h_c without a jump being formed.
h_n
h_c
h_c
B
C
L
Jump position.
Control at exit, h = h_c
Theoretical profiles based on h = h_c at exit and E = terminal E at L = zero

Note: Water surface profiles approach h_n rapidly from an initial condition $h = h_c$.

Figure 5. Control depths employed in determining water surface profiles upstream and downstream of a pipe slope change.



$F_1 = \rho g A_1 \bar{h}_1$

$F_2 = \rho g A_2 h_2$

$M_1 = (\rho A_1 V_1) V_1$

$M_2 = (\rho A_2 V_2) V_2$

$\bar{h}_{1,2}$ - centroid depth = f(channel shape)

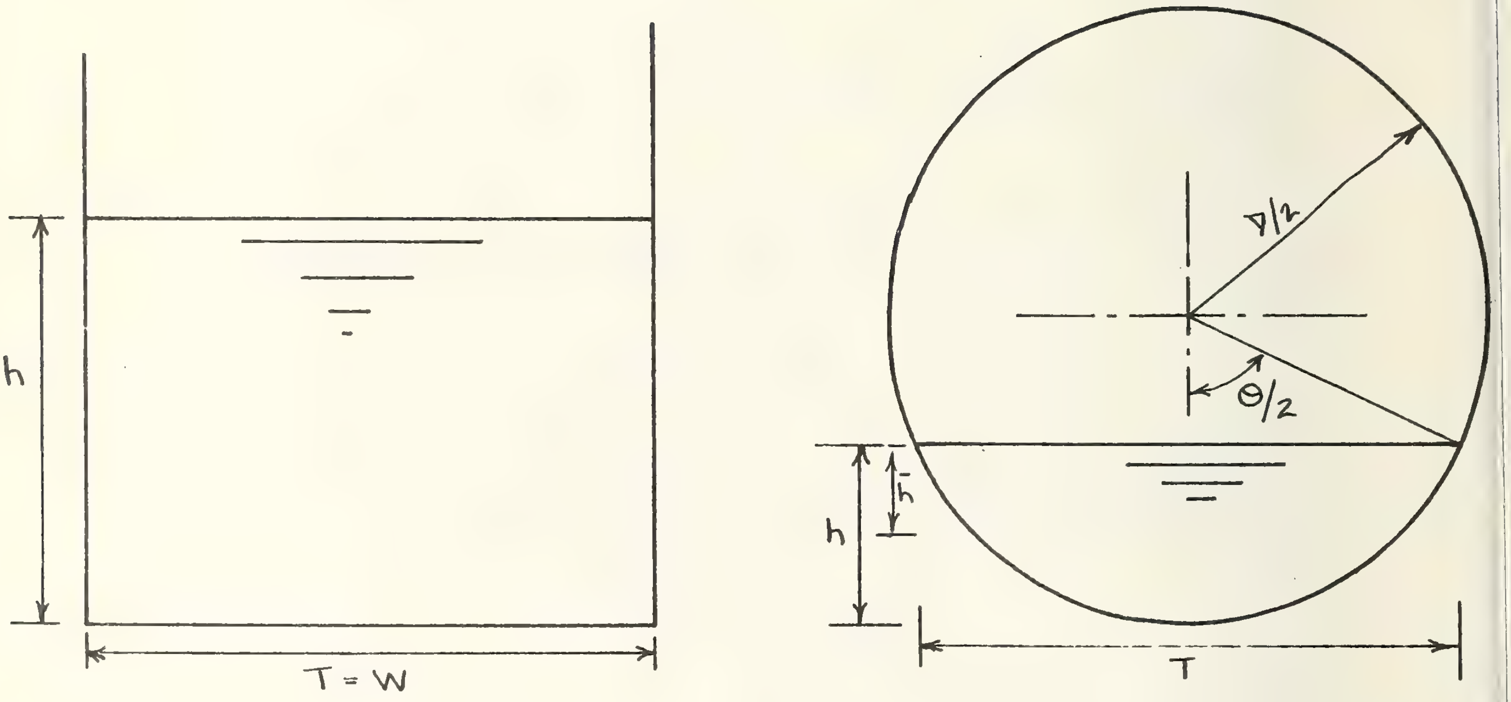
$F_{1,2}$ - hydrostatic forces

$M_{1,2}$ - momentum crossing control volume boundaries at 1,2

Jump occurs if $(F+M)_1 = (F+M)_2$.

Depths h_1, h_2 known as conjugate depths.

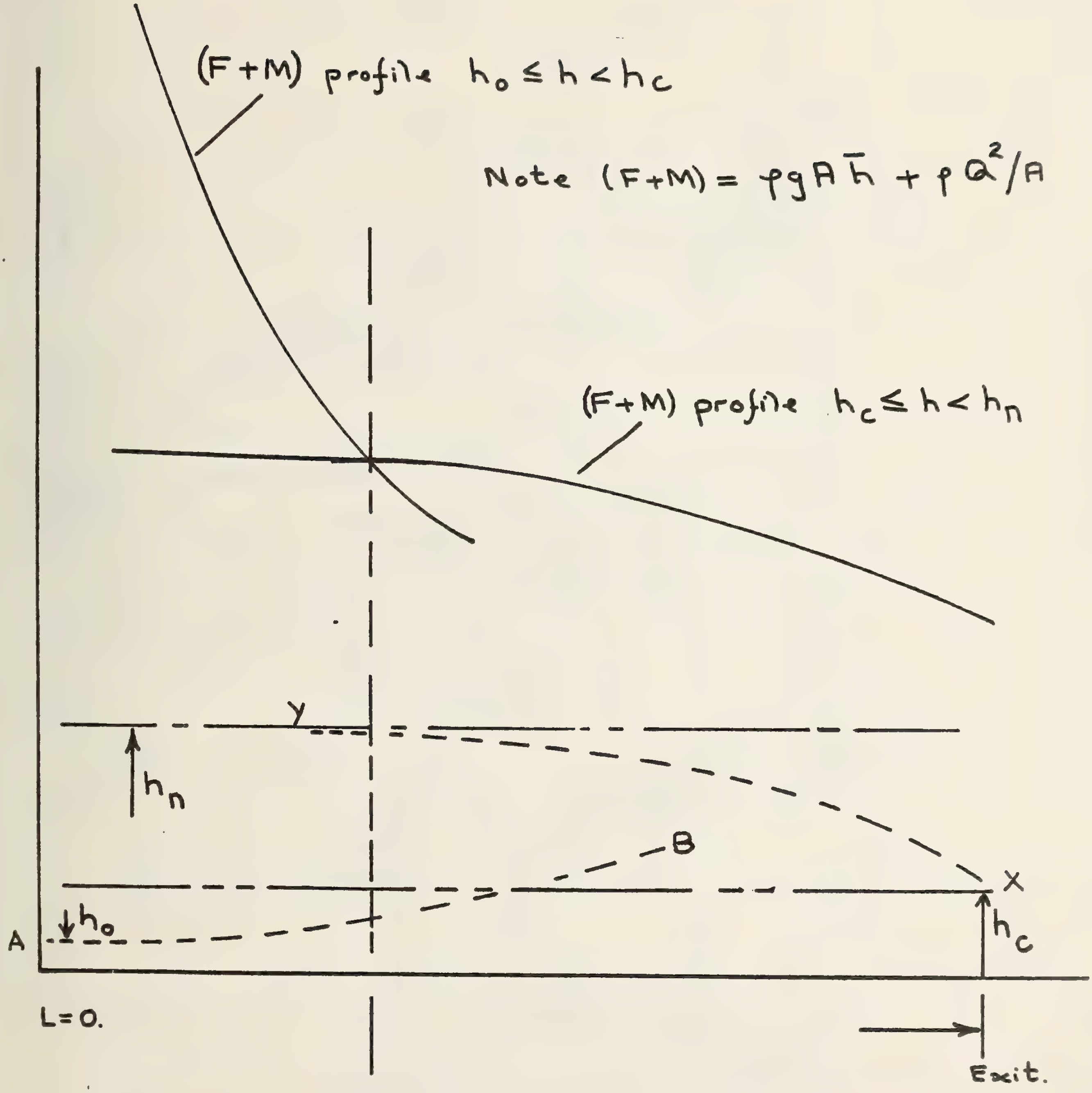
Figure 6. Forces acting at the jump location in a horizontal, or near horizontal channel.



Depth	$= h$	$= h$
Area	$= h \times w$	$= (D^2/8) \times (\theta - \sin\theta)$
Surface width T	$= w$	$= 2.0 \times \sqrt{h \times (D - h)}$
Perimeter	$= 2h + w$	$= D \times \theta/2$
Centroid depth $\bar{h}$	$= h/2$	$= h - D/2 + X_o$

$$X_o = \frac{2}{3} \times \frac{D}{2} \times \left(\frac{3 \times \sin\theta 2 - \sin 3\theta/2}{4 \times (\theta/2 - \frac{1}{2} \times \sin\theta)}\right)$$

Figure 7. Summary of duct cross section parameter calculations.

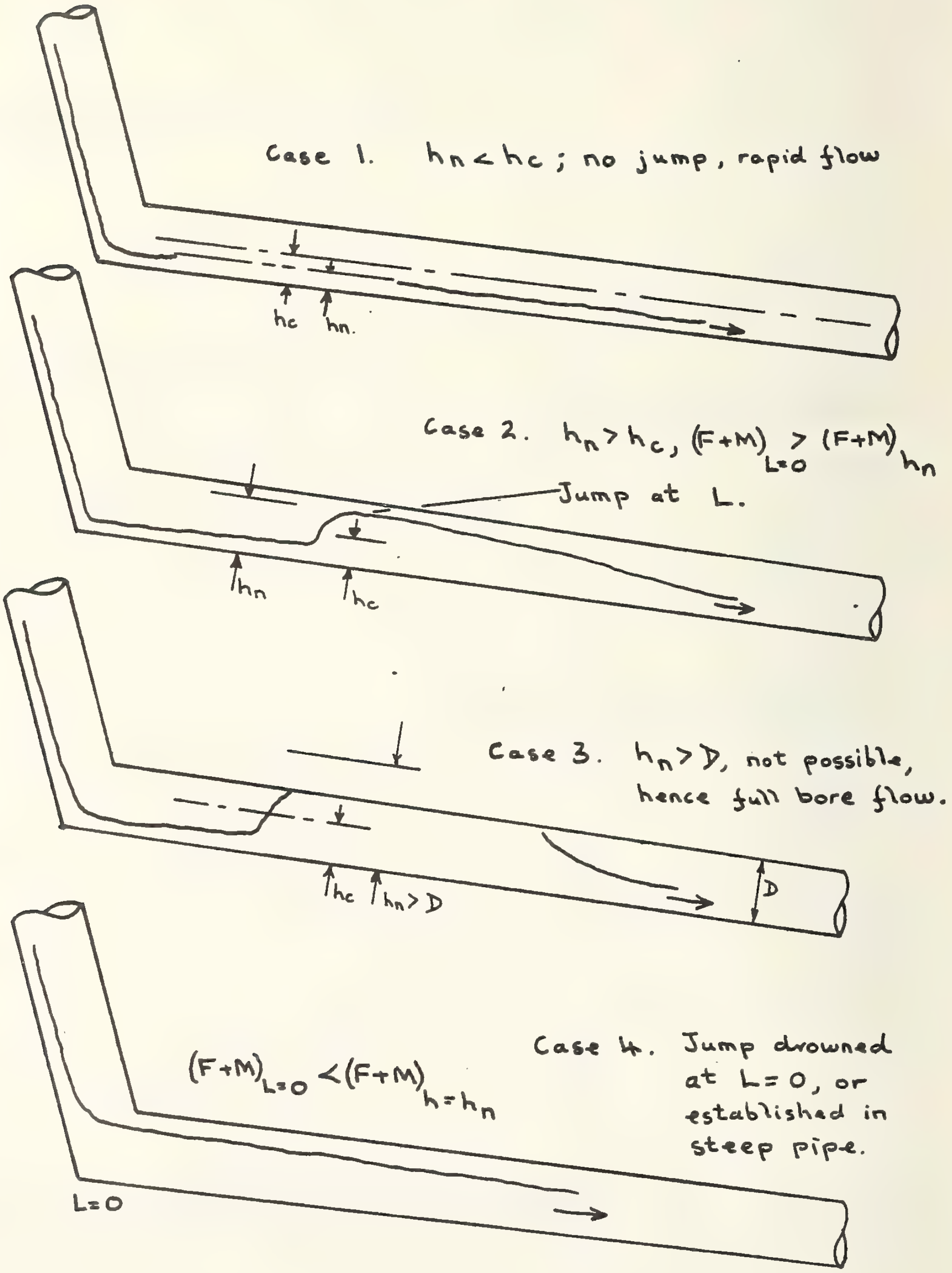

(F+M) profile $h_o \le h < h_c$
(F+M) profile $h_c \le h < h_n$
Y
h_n
B
X
A
h_o
h_c
L=0.
Exit.

Note $(F+M) = \rho g A \bar{h} + \rho Q^2/A$

Profile AB calculated from h_o with $(h_c - h_o)/N$ as Δh value.

Profile XY calculated from h_c with $(h_n - h_c)/N$ as Δh value

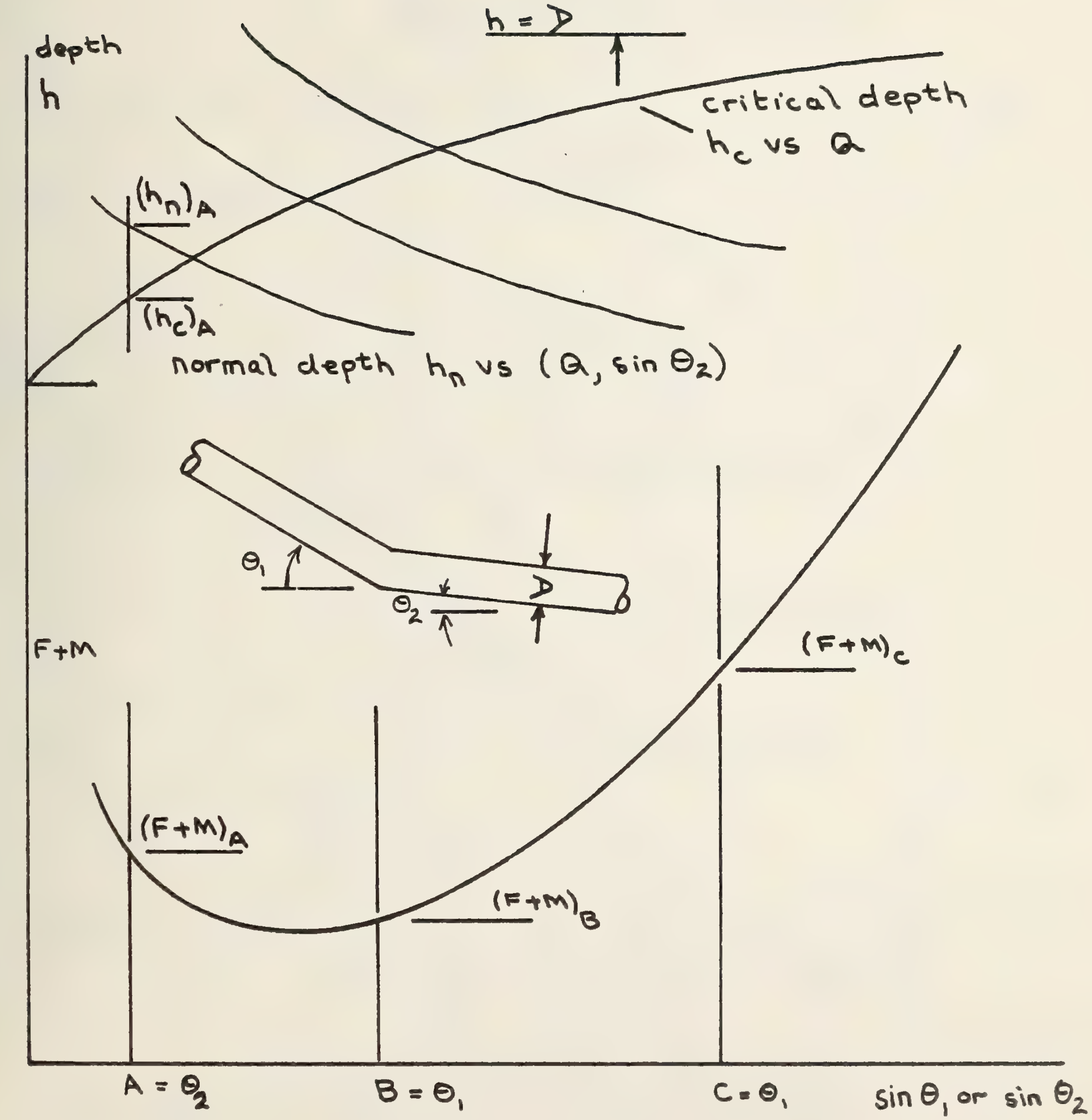
Figure 8. Water surface profiles and associated (F+M) profiles employed to position hydraulic jump.


Case 1. hn < hc ; no jump, rapid flow
hc
hn.
Case 2. $h_n > h_c$, $(F+M)_{L=0} > (F+M)_{h_n}$
Jump at L.
hn
hc
Case 3. $h_n > D$, not possible, hence full bore flow.
hc
hn > D
D
Case 4. Jump drowned at L = 0, or established in steep pipe.
$(F+M)_{L=0} < (F+M)_{h=h_n}$
L=0

Note: h_c given by: $Q^2T/gA^3 - 1 = 0$

Note: h_n given by: $S_o - (n\ Q/Am^{2/3})^2 = 0$

Figure 9. Conditions governing jump formation.



Note: if $(F+M)_A > (F+M)_B$ or C, jump drowned at L=0.
if $(F+M)_A < (F+M)_B$ or C, jump possible.
if $(h_n)_A < (h_c)_A$ jump impossible.
if $(h_n)_A > D$, full backflow.

Figure 10. Tests employed to determine the possibility of jump formation.

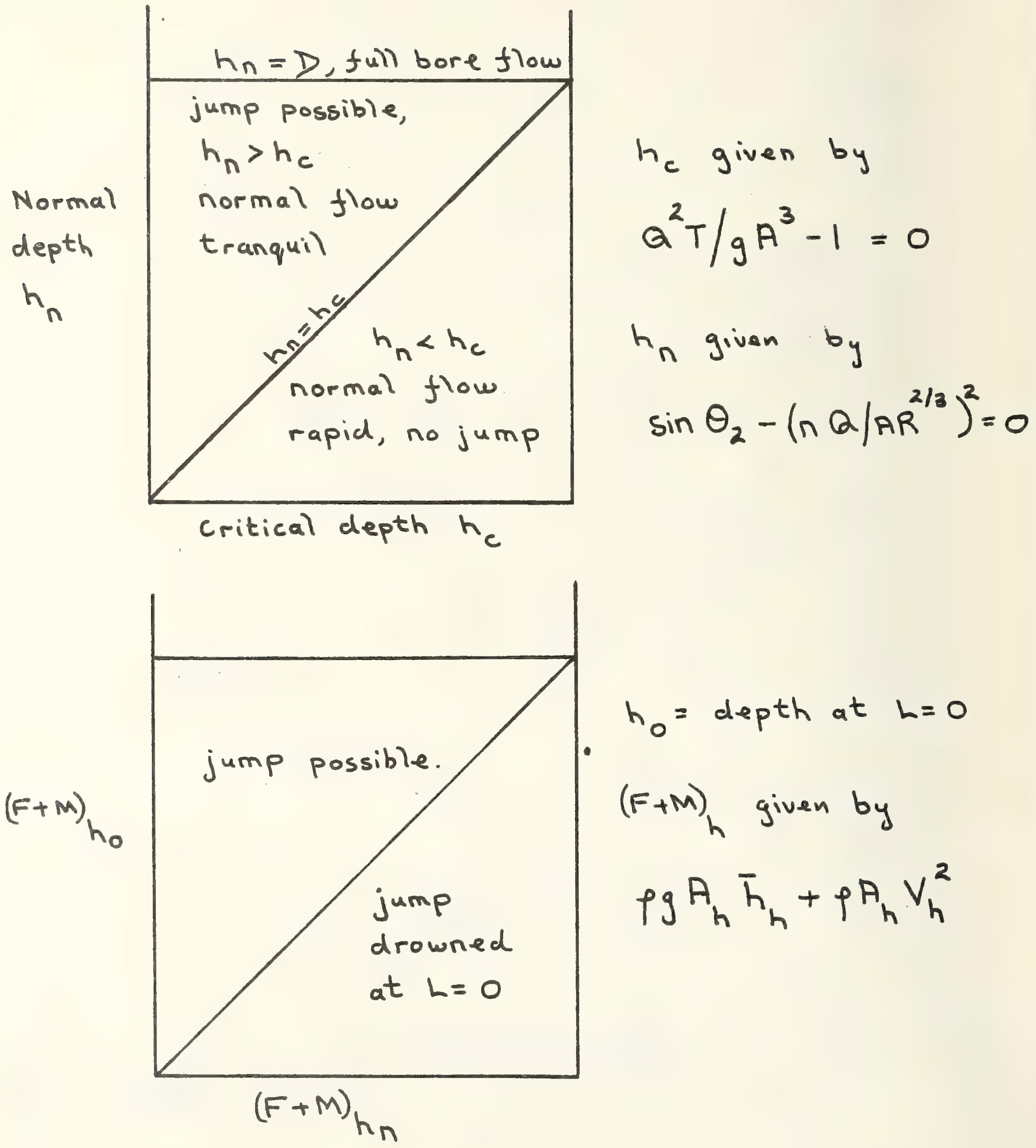


Figure 11. Schematic representation of jump boundary conditions.

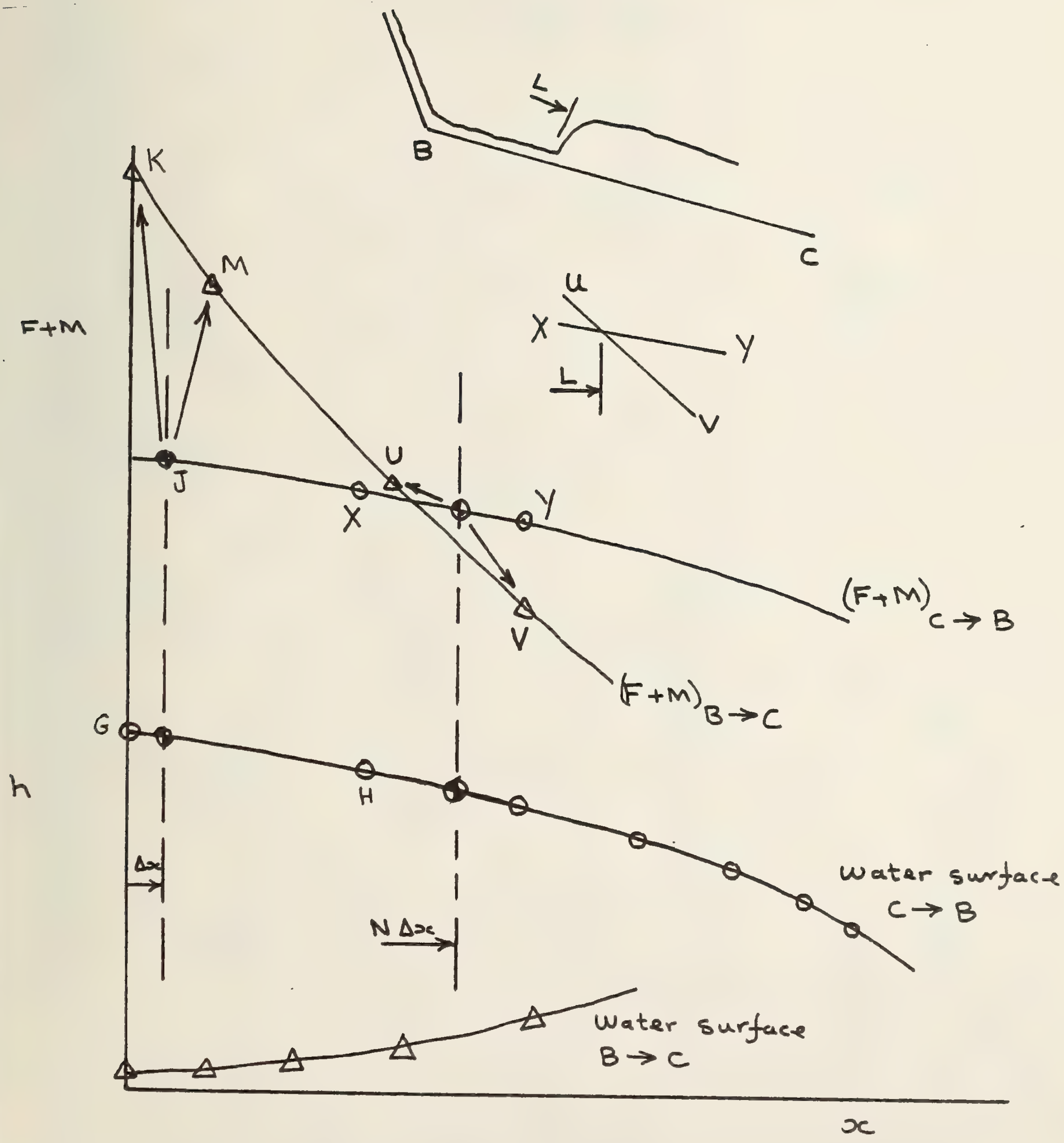


Figure 12. Schematic representation of jump position identification technique employed.

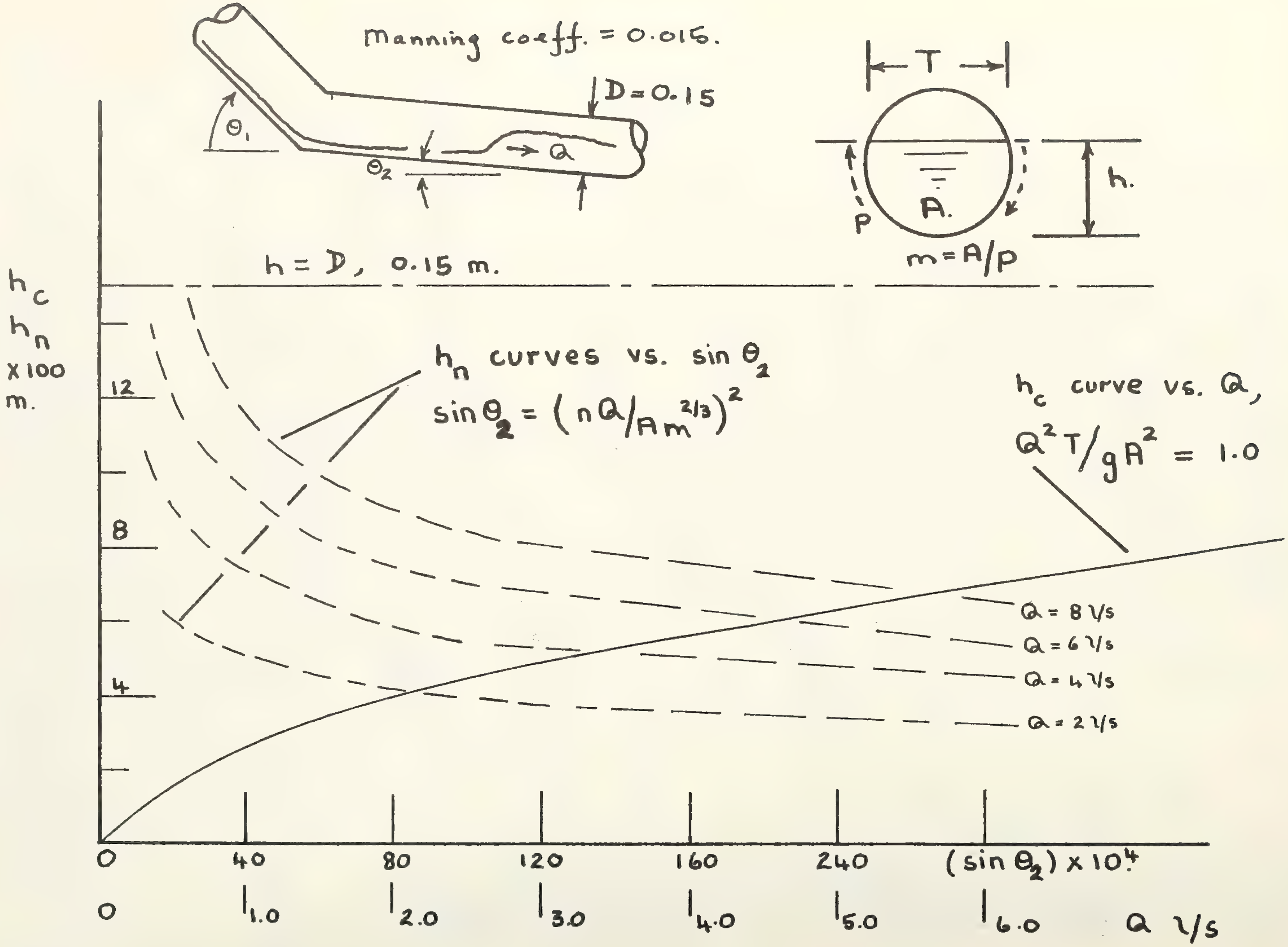


Figure 13. Variation of normal depth, h_n, and critical depth, h_c, with flow rate Q and test pipe slope θ_2. Note values independent of θ_1.

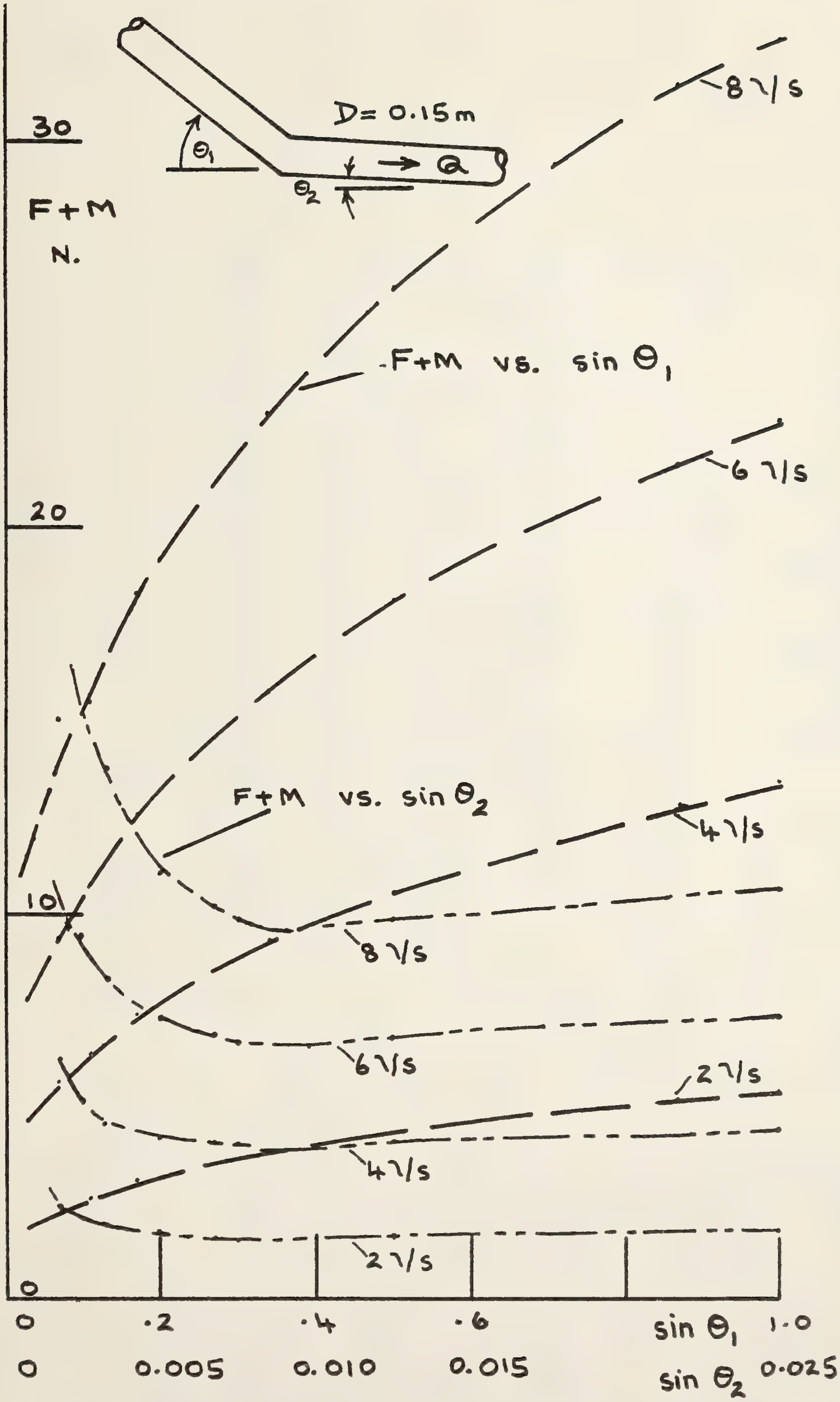


Figure 14. Variation of (F+M) term with pipe slope and flow rate. D = 0.15, n = 0.015.

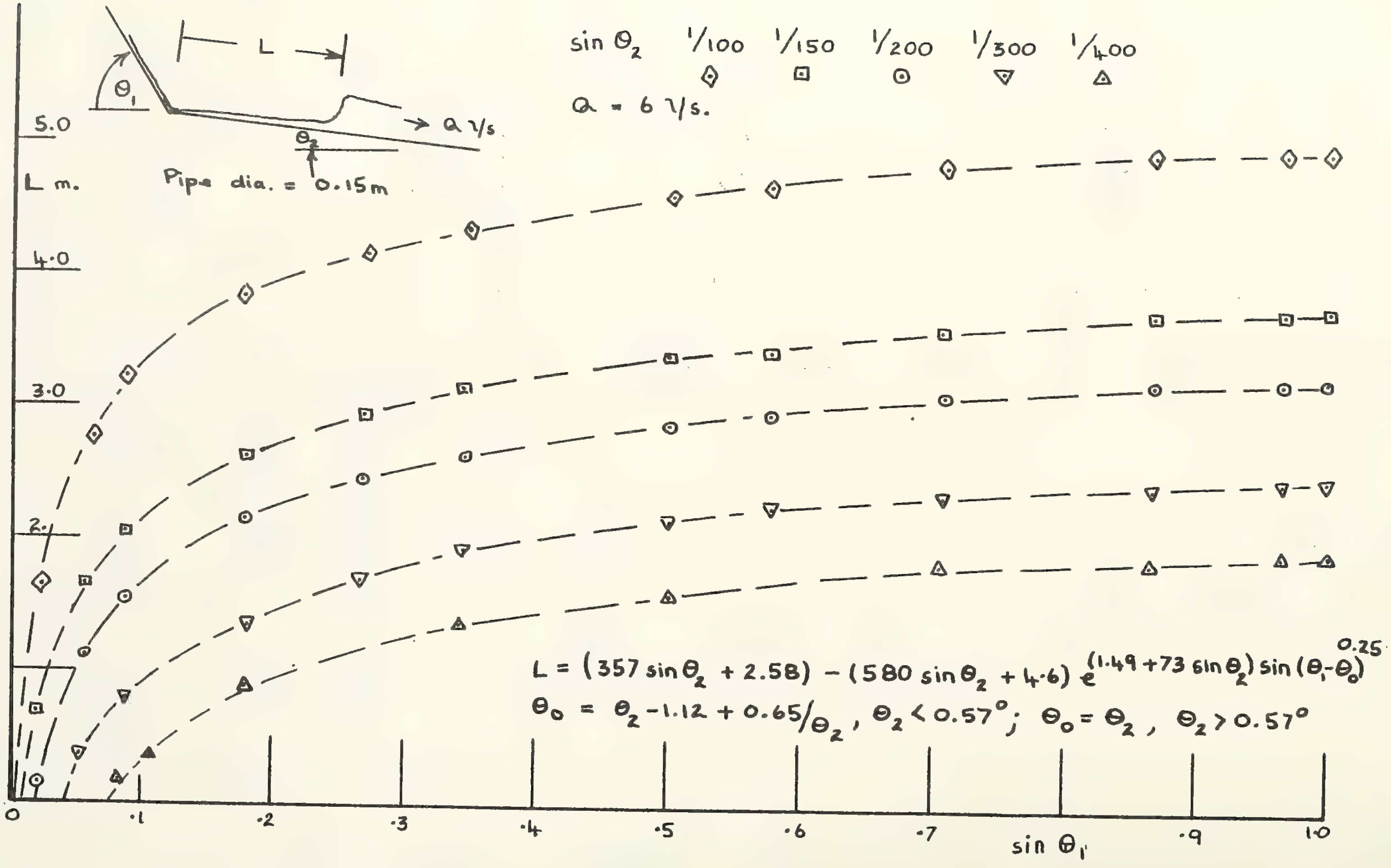


Figure 15. Jump location as a function of pipe slopes θ_1, θ_2 for constant $Q = 6\,(1/s)$ $D = 0.15$ and Manning coefficient = 0.015.

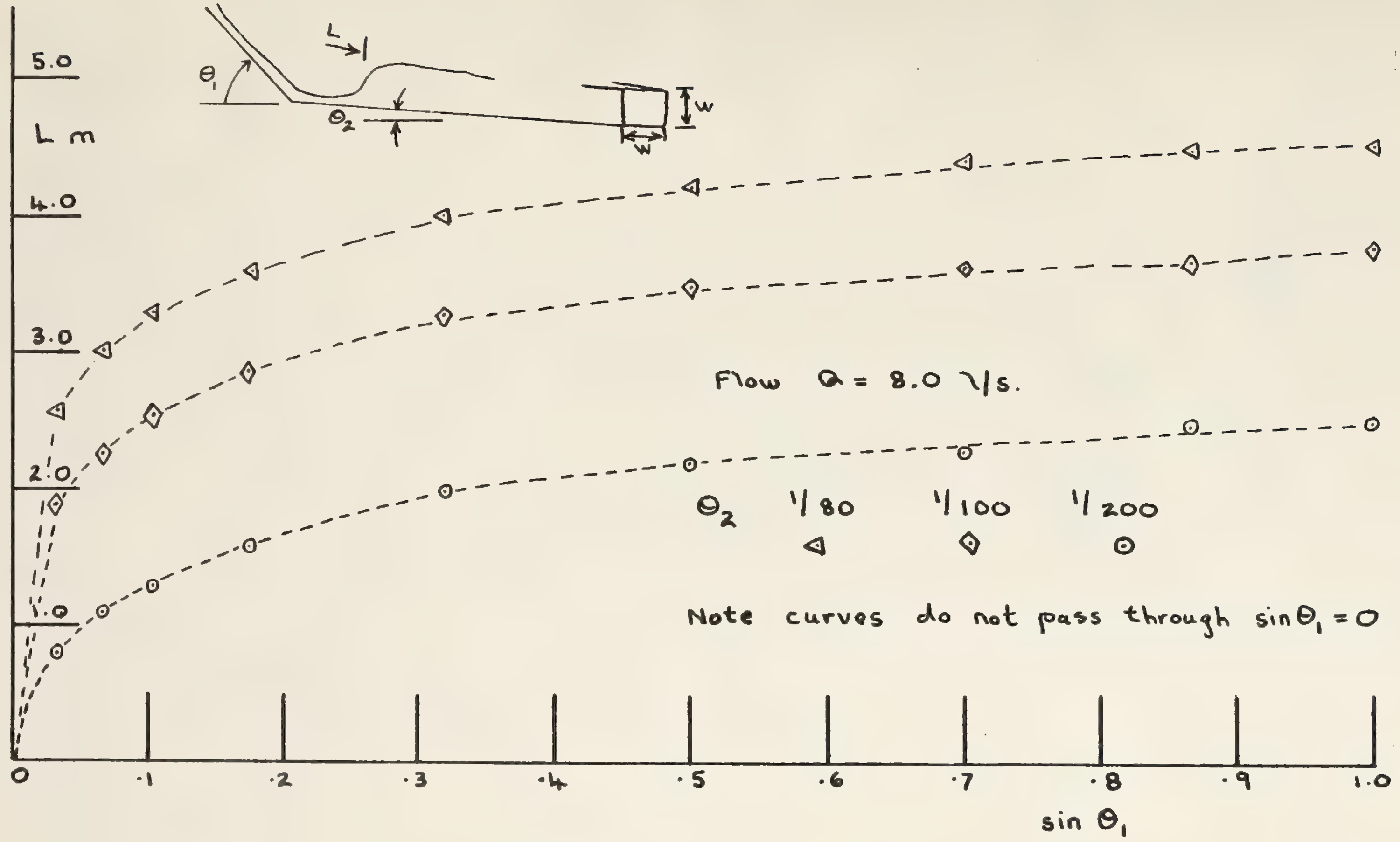


Figure 16. Variation of jump position with test pipe slope 1/80 - 1/200. Flow constant at Q = 8.0 l/s W = 0.15 m, n = 0.015. Rectangular channel results.

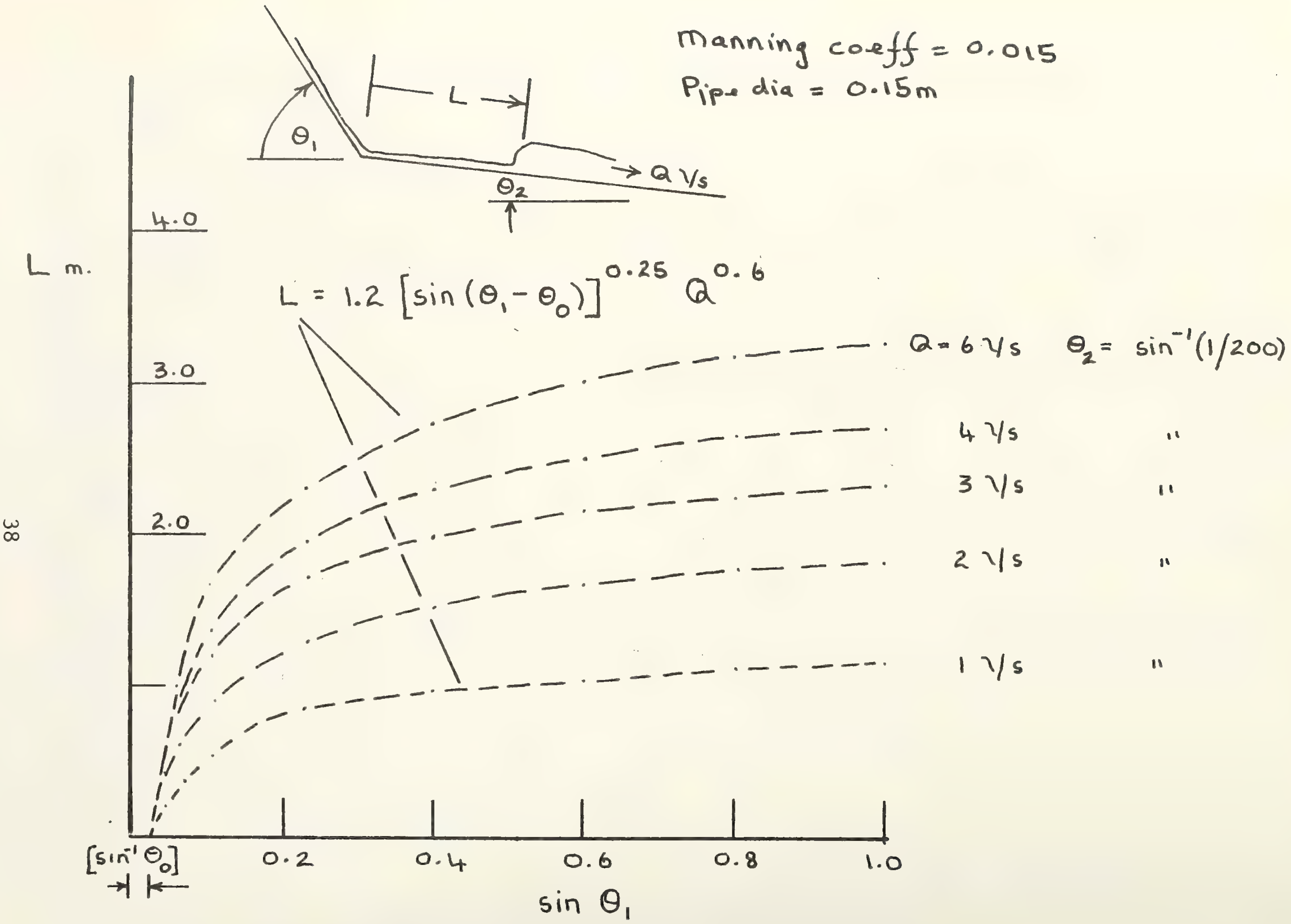


Figure 17. Variation of jump location with flow rate Q and approach pipe slope θ_1, for constant D = 0.015 m, n = 0.015 and 1/200 test pipe slope.

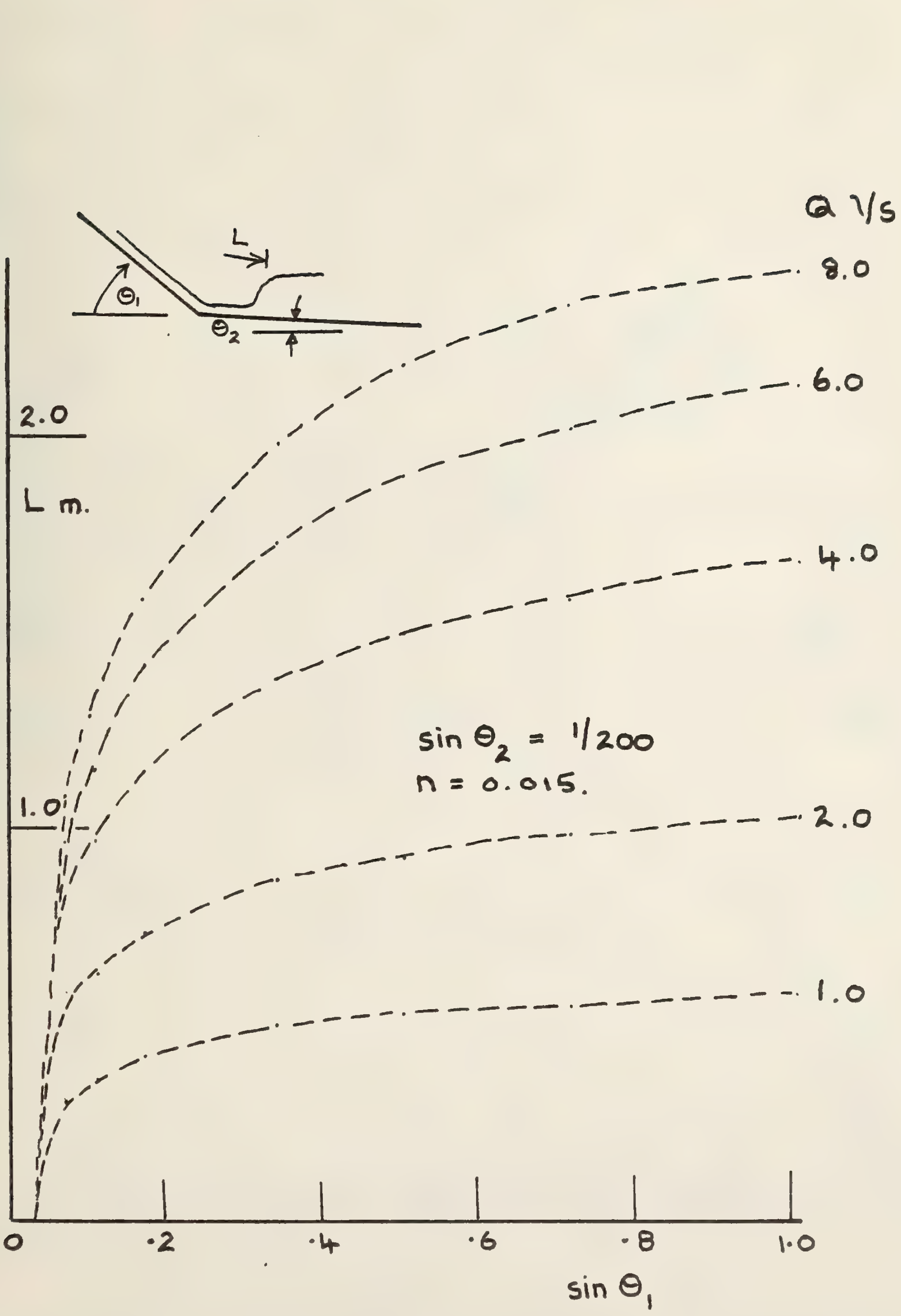
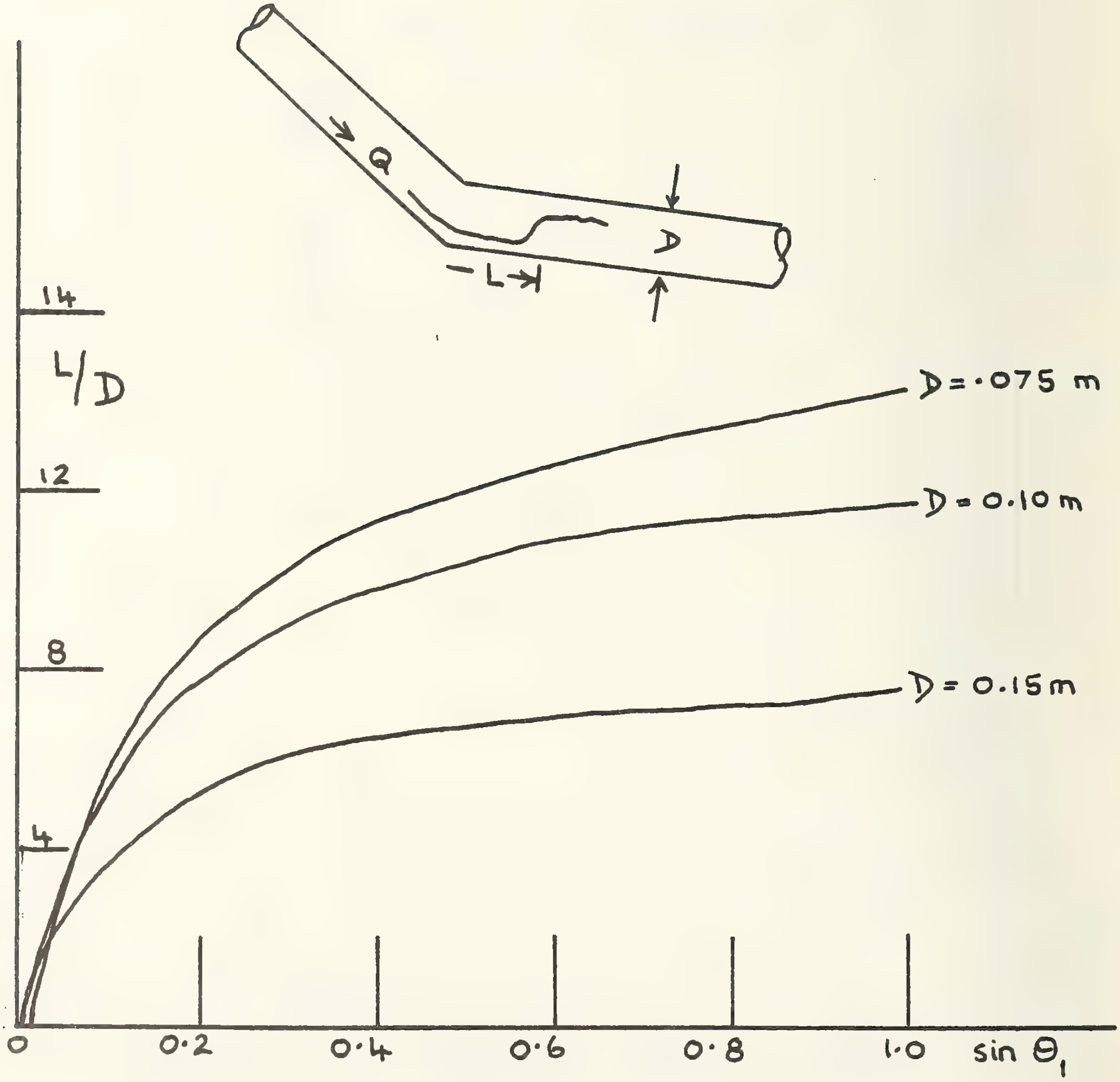
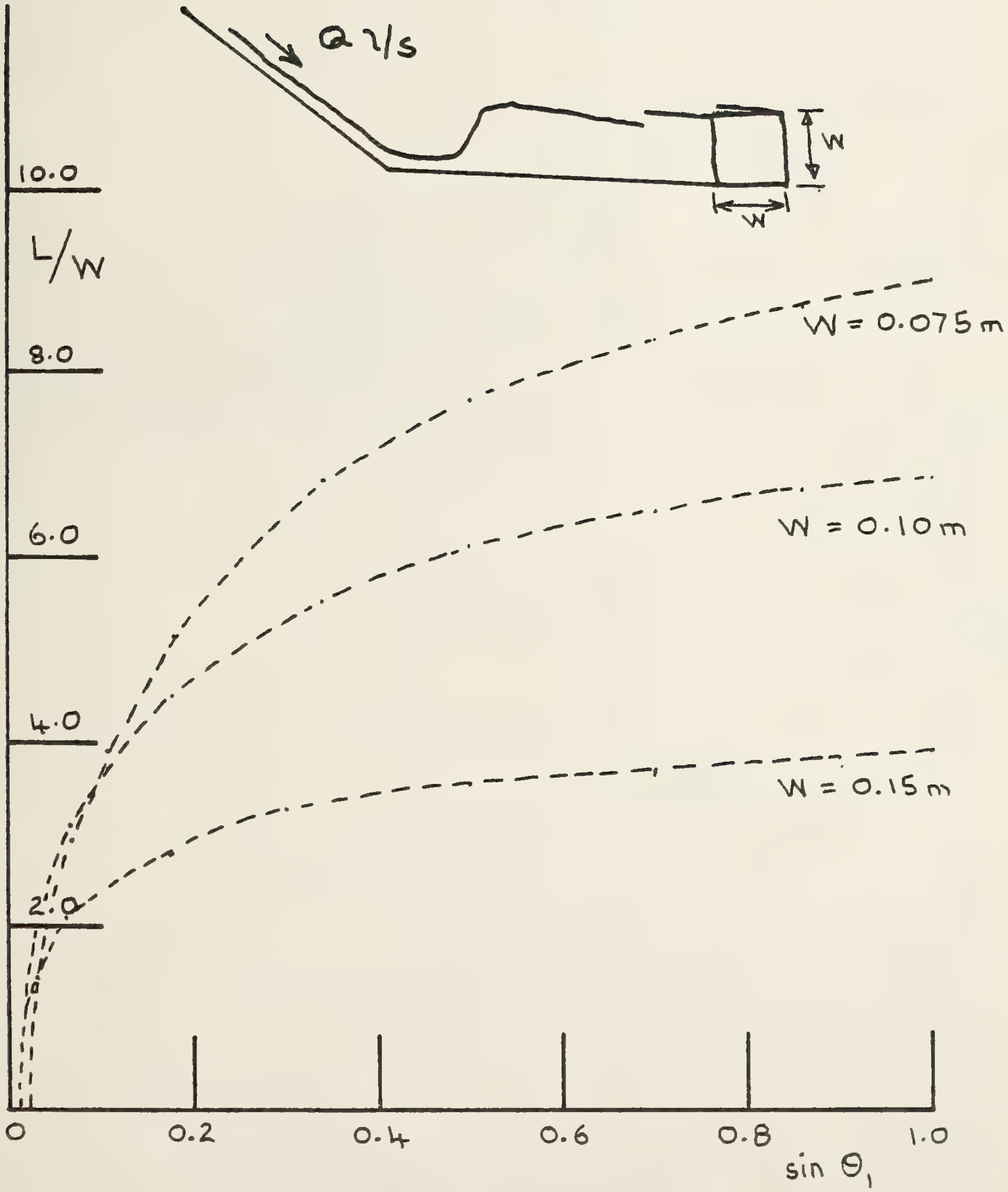


Figure 18. Jump position in a rectangular channel, width 0.15 m, slope 1/200, as a function of flow rate and approach pipe slope.



Note curves do not pass through L = 0.

Figure 19. Pipe diameter effect at Q = 1(l/s) $\theta_2 = \sin^{-1}(0.005)$, Manning coefficient = 0.015.



Note curves do not pass through L/W = 0.

Figure 20. Channel width effect at $Q = 1(l/s)$ $\theta_2 = \sin^{-1}(0.005)$, Manning coefficient = 0.015.

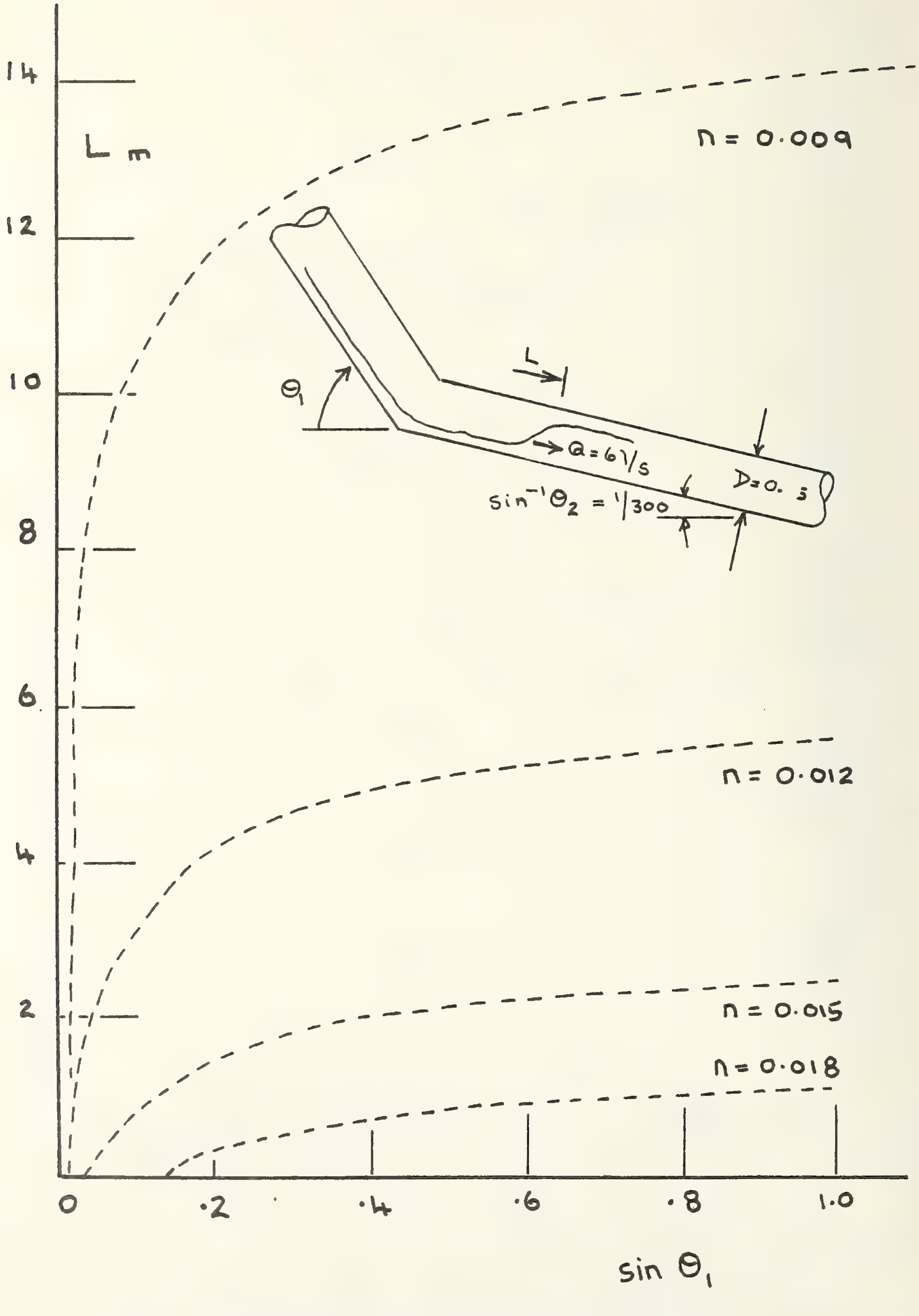


Figure 21. Effect of Manning coefficient n on jump location in a pipe at 1/300 with a flow rate of 6 (l/s). Pipe 0.15 m diameter.

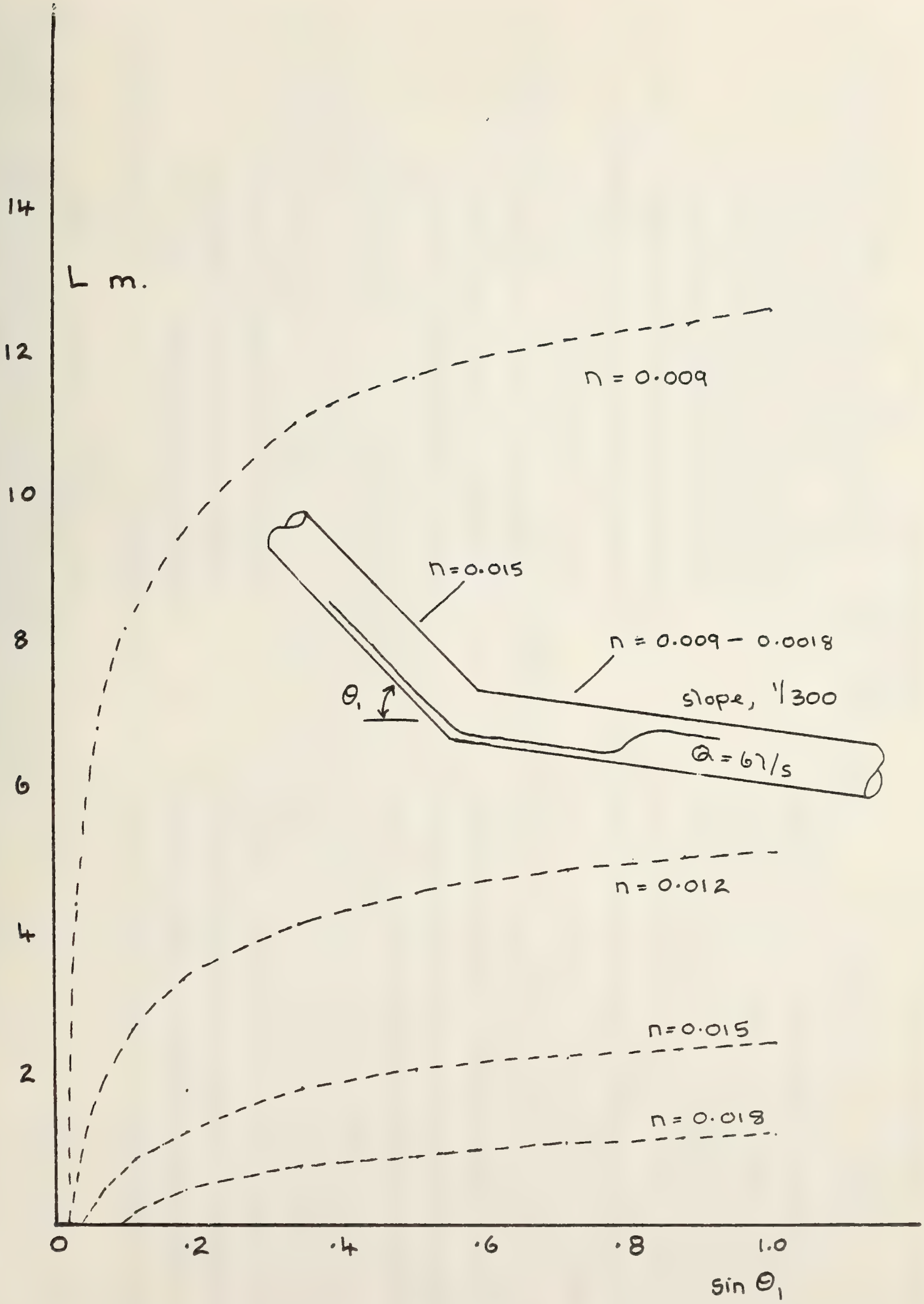


Figure 22. Manning coefficient effect. Note: n constant for approach pipe at 0.015.

```
 COMMON DATA  APPROACH PIPE DATA                                    TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                 M.                          M.    M.    M.    M.    M.    M.

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0250 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0250 0.079 0.071                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0250 0.065 0.054                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0250 0.045 0.036                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.7070 0.011 0.229 0.0250 0.031 0.025                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0125 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0125 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0125 0.065 0.068 0.022  0.4912.216 0.062 0.068  0.005  0.093  0.093 -0.000 4.477 3.443

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0125 0.045 0.044                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.7070 0.011 0.229 0.0125 0.031 0.030                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0100 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0100 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0100 0.065 0.074 0.022  0.4912.216 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 2.936

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0100 0.045 0.047 0.016  0.33 4.983 0.044 0.047  0.003  0.062  0.062 -0.000 1.808 2.356

 1.0 0.10 0.015 0.7070 0.011 0.229 0.0100 0.031 0.032 0.011  0.21 2.016 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.621

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0050 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0050 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0050 0.065 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0050 0.045 0.058 0.016  0.33 4.983 0.035 0.058  0.023  0.070  0.067 -0.003 1.994 1.555



 1.0 0.10 0.015 0.7070 0.011 0.229 0.0050 0.031 0.039 0.011  0.21 2.016 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 1.335
```

Table 1. Jump location in a 0.1 m diameter partially filled pipe at an approach pipe slope of 45°.

```
 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  WIDTH MANN. SLOPE    HN   TERM.  SLOPE    HC      HN   ENTRY ENTRY ENTRY UPJUMP JUMN   DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
_/S  M.    COEFF (SIN)    M.   ENERGY (SIN)    M.      M.   DEPTH ENERGY F*M  DEPTH  DEPTH  CHANGE UPJUMP DOWN   CHANGE F*M.  POS.
                                 M.                          M.    M.     M.    M.     M.     M.      M.     M.     M.    M.    M.

8.0 0.10 0.015 0.7070 0.023 0.651 0.0250 0.087 0.078                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.10 0.015 0.7070 0.019 0.541 0.0250 0.072 0.062                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.7070 0.014 0.412 0.0250 0.055 0.046                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.7070 0.009 0.254 0.0250 0.034 0.028                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.7070 0.006 0.153 0.0250 0.022 0.017                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.7070 0.023 0.651 0.0125 0.087 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.7070 0.019 0.541 0.0125 0.072 0.081 0.013  0.5619.720 0.063 0.081  0.019  0.109  0.109 -0.000 7.675 2.935

4.0 0.10 0.015 0.7070 0.014 0.412 0.0125 0.055 0.059 0.014  0.4311.471 0.050 0.059  0.009  0.083  0.083 -0.000 4.425 2.521

2.0 0.10 0.015 0.7070 0.009 0.254 0.0125 0.034 0.036 0.009  0.26 4.504 0.034 0.036  0.002  0.052  0.052 -0.000 1.745 1.311

1.0 0.10 0.015 0.7070 0.006 0.153 0.0125 0.022 0.022 0.006  0.16 1.749 0.022 0.022  0.000  0.033  0.033 -0.000 0.692 1.187

8.0 0.10 0.015 0.7070 0.023 0.651 0.0100 0.087 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.7070 0.019 0.541 0.0100 0.072 0.089 0.019  0.5619.720 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 2.552

4.0 0.10 0.015 0.7070 0.014 0.412 0.0100 0.055 0.065 0.014  0.4311.471 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 2.133



2.0 0.10 0.015 0.7070 0.009 0.254 0.0100 0.034 0.039 0.009  0.26 4.504 0.031 0.039  0.008  0.052  0.052 -0.000 1.766 1.561

1.0 0.10 0.015 0.7070 0.006 0.153 0.0100 0.022 0.024 0.006  0.16 1.749 0.020 0.024  0.004  0.033  0.033 -0.000 0.697 0.935

8.0 0.10 0.015 0.7070 0.023 0.651 0.0050 0.087 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.7070 0.019 0.541 0.0050 0.072 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.7070 0.014 0.412 0.0050 0.055 0.085 0.014  0.4311.471 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 1.354

2.0 0.10 0.015 0.7070 0.009 0.254 0.0050 0.034 0.050 0.009  0.26 4.504 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 0.935

1.0 0.10 0.015 0.7070 0.006 0.153 0.0050 0.022 0.030 0.006  0.16 1.749 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.545
```

Table 2. Jump location in a 0.1 m wide channel at an approach pipe slope of 45°

Table 3. Schematic of Tabulated Jump Boundary Conditions.

Flow rate Q	Q_1	$Q_2 \dots Q_1$		D Pipe diameter
Test pipe slope S = sin θ_2		Normal flow depth, Q, S values.		
S_1		hn_{12}	c f	D
S_2		hn_{22}		D
.		.		
.		.		
.		.		
Si		hn_{i2}		D
Critical depth hc = f(Q)	hc_1	hc_2	cf hc_i	
Flow rate Q Test pipe slope	Q_1	Q_2 (F+M) test pipe normal depth value	Q_i	
S_1		$(F+M)_{12}$		
.		.		c_f
S_3		.		
.		.		
S_i		$(F+M)_{i2}$		
Approach pipe slope U		$(F+M)^*$ terminal (i.e. test pipe entry)		
U_1		$(F+M)*_{12}$		
U_2		$(F+M)*_{22}$		
.		.		
.		.		
.		.		
U_i		$(F+M*_{i2}$		

APPENDIX 1

JUMP LOCATION IN A 0.075 m DIAMETER PIPE, MANNING COEFFICIENT 0.015, AT SLOPES 1/40, 1/80, 1/100, 1/200

```
 COMMON DATA  APPROACH PIPE DATA                                TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                 M.                          M.    M.    M.    M.     M.    M.      M.     M.     M.     M.    M.

 8.0 0.07 0.015 0.0349 0.075 0.242 0.0250 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.0349 0.075 0.169 0.0250 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0349 0.054 0.115 0.0250 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0349 0.038 0.078 0.0250 0.049 0.042                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.0349 0.026 0.054 0.0250 0.034 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.0349 0.075 0.242 0.0125 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.0349 0.075 0.169 0.0125 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0349 0.064 0.115 0.0125 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0349 0.038 0.078 0.0125 0.049 0.054 0.033  0.08 2.127 0.045 0.054  0.008  0.072  0.071 -0.000 1.971 0.463

 1.0 0.07 0.015 0.0349 0.026 0.054 0.0125 0.034 0.034 0.026  0.05 0.873 0.034 0.034  0.000  0.047  0.047  0.    0.787 0.553

 8.0 0.07 0.015 0.0349 0.075 0.242 0.0100 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 5.0 0.07 0.015 0.0349 0.075 0.169 0.0100 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0349 0.064 0.115 0.0100 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0349 0.038 0.078 0.0100 0.049 0.059 0.038  0.08 2.127 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 0.153

 1.0 0.07 0.015 0.0349 0.026 0.054 0.0100 0.034 0.037 0.025  0.05 0.873 0.032 0.037  0.005  0.048  0.048 -0.000 0.793 0.334

 8.0 0.07 0.015 0.0349 0.075 0.242 0.0050 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.0349 0.075 0.169 0.0050 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0349 0.064 0.115 0.0050 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.



 2.0 0.07 0.015 0.0349 0.038 0.078 0.0050 0.049 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 1.0 0.07 0.015 0.0349 0.026 0.054 0.0050 0.034 0.045                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 COMMON DATA  APPROACH PIPE DATA                                 TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE   HM  TERM.  SLOPE    HC     HM  ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH   ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)   M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F*M  DEPTH DEPTH CHANGE  UPJUMP DOWN   CHANGE F*M.  POS.
                              M.                           M.    M.    N.    M.    M.    M.       M.    M.      M.    N.    M.

 8.0 0.07 0.015 0.0698 0.075 0.242 0.0250 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.0698 0.075 0.169 0.0250 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0698 0.047 0.141 0.0250 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.031 0.098 0.0250 0.049 0.042                 JUMP IMPOSSIBLE AS HM<HC IN TEST PIPE.

 1.0 0.07 0.015 0.0698 0.022 0.067 0.0250 0.034 0.028                 JUMP IMPOSSIBLE AS HM<HC IN TEST PIPE.

 8.0 0.07 0.015 0.0698 0.075 0.242 0.0125 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.0698 0.075 0.169 0.0125 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0698 0.047 0.141 0.0125 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.031 0.098 0.0125 0.049 0.054 0.031  0.10 2.500 0.045 0.054  0.008  0.072  0.071 -0.000 1.971 0.775

 1.0 0.07 0.015 0.0698 0.022 0.067 0.0125 0.034 0.034 0.022  0.07 1.034 0.034 0.034  0.000  0.047  0.047 -0.000 0.787 1.038

 8.0 0.07 0.015 0.0698 0.075 0.242 0.0100 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.0698 0.075 0.169 0.0100 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0698 0.047 0.141 0.0100 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.031 0.098 0.0100 0.049 0.059 0.031  0.10 2.500 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 0.552

 1.0 0.07 0.015 0.0698 0.022 0.067 0.0100 0.034 0.037 0.024  0.07 1.034 0.032 0.037  0.005  0.048  0.048 -0.000 0.773 0.741

 8.0 0.07 0.015 0.0698 0.075 0.242 0.0050 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.0698 0.075 0.169 0.0050 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.0698 0.047 0.141 0.0050 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.031 0.098 0.0050 0.049 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 1.0 0.07 0.015 0.0698 0.022 0.067 0.0050 0.034 0.045 0.022  0.07 1.034 0.025 0.045  0.020  0.055  0.052 -0.003 0.696 0.257
 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE   HN  TERM.  SLOPE    HC    HN  ENTRY ENTRY ENTRY UPJUMP JUMN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COFF  (SIN)   M.  ENERGY (SIN)    M.    M.  DEPTH ENERGY F+M  DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                M.                      M.     M.    M.    M.    M.     M.      M.    M.      M.    M.    M.

 8.0 0.07 0.015 0.1045 0.075 0.242 0.0250 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.1045 0.055 0.206 0.0250 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.1045 0.042 0.170 0.0250 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.028 0.118 0.0250 0.049 0.042                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.1045 0.020 0.080 0.0250 0.034 0.028                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.1045 0.075 0.242 0.0125 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.1045 0.055 0.206 0.0125 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.1045 0.042 0.170 0.0125 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.028 0.118 0.0125 0.049 0.054 0.028  0.12 2.817 0.045 0.054  0.008  0.072  0.071 -0.003 1.971 1.253

 1.0 0.07 0.015 0.1045 0.020 0.080 0.0125 0.034 0.034 0.023  0.08 1.142 0.034 0.034  0.000  0.047  0.047 -0.000 0.787 1.135

 8.0 0.07 0.015 0.1045 0.075 0.242 0.0100 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.1045 0.055 0.206 0.0100 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.1045 0.042 0.170 0.0100 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.028 0.118 0.0100 0.049 0.059 0.028  0.12 2.817 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 0.923

 1.0 0.07 0.015 0.1045 0.020 0.080 0.0100 0.034 0.037 0.023  0.08 1.142 0.032 0.037  0.005  0.048  0.048 -0.000 0.793 0.995

 8.0 0.07 0.015 0.1045 0.075 0.242 0.0050 0.074 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.1045 0.055 0.206 0.0050 0.073 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.1045 0.042 0.170 0.0050 0.067 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.028 0.118 0.0050 0.049 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 1.0 0.07 0.015 0.1045 0.020 0.080 0.0050 0.034 0.045 0.023  0.08 1.142 0.025 0.045  0.020  0.055  0.052 -0.003 0.676 0.433
```

```
   COMMON DATA  APPROACH PIPE DATA                           TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE   HN   TERM.  SLOPE   HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)   M.  ENERGY  (SIN)   M.     M.  DEPTH ENERGY F+M  DEPTH DEPTH CHANGE UPJUMP DOWN  CHANGE F+M.  POS.
                             M.                          M.    M.    N.    M.    M.     M.      M.     M.     M.    N.    M.

 8.0 0.07 0.015 0.1736 0.057 0.309 0.0250 0.074 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.07 0.015 0.1736 0.046 0.274 0.0250 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 4.0 0.07 0.015 0.1736 0.036 0.224 0.0250 0.067 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.


 2.0 0.07 0.015 0.1736 0.025 0.154 0.0250 0.049 0.042             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.07 0.015 0.1736 0.017 0.104 0.0250 0.034 0.028             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.07 0.015 0.1736 0.057 0.309 0.0125 0.074 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.07 0.015 0.1736 0.046 0.274 0.0125 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 4.0 0.07 0.015 0.1736 0.036 0.224 0.0125 0.067 0.075             FULL BORE FLOW ESTAB_ISHED IN TEST PIPE.
 2.0 0.07 0.015 0.1736 0.025 0.154 0.0125 0.049 0.054 0.025  0.15 3.274 0.045 0.054  0.008  0.072  0.071 -0.000 1.971 1.537
 1.0 0.07 0.015 0.1736 0.017 0.104 0.0125 0.034 0.034 0.017  0.10 1.356 0.034 0.034  0.000  0.047  0.047 -0.000 0.787 1.413
 8.0 0.07 0.015 0.1736 0.057 0.309 0.0100 0.074 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.07 0.015 0.1736 0.046 0.274 0.0100 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 4.0 0.07 0.015 0.1736 0.036 0.224 0.0100 0.067 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 2.0 0.07 0.015 0.1736 0.025 0.154 0.0100 0.049 0.059 0.025  0.15 3.274 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 1.137
 1.0 0.07 0.015 0.1736 0.017 0.104 0.0100 0.034 0.037 0.017  0.10 1.356 0.032 0.037  0.005  0.048  0.048 -0.000 0.773 1.133
 8.0 0.07 0.015 0.1736 0.057 0.309 0.0050 0.074 0.075             FULL BORE FLOW ESTAB_ISHED IN TEST PIPE.
 6.0 0.07 0.015 0.1736 0.046 0.274 0.0050 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 4.0 0.07 0.015 0.1736 0.036 0.224 0.0050 0.067 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 2.0 0.07 0.015 0.1736 0.025 0.154 0.0050 0.049 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 1.0 0.07 0.015 0.1736 0.017 0.104 0.0050 0.034 0.045 0.017  0.10 1.356 0.025 0.045  0.020  0.055  0.052 -0.003 0.896 0.537
 COMMON DATA  APPROACH PIPE DATA                            TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN   TERM.  SLOPE   HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)   M.   ENERGY (SIN)   M.     M.  DEPTH ENERGY F.M  DEPTH DEPTH CHANGE UPJUMP DOWN  CHANGE F.M.  POS.
                              M.                         M.    M.     N.    M.    M.     M.      M.    M.      M.    N.    M.

 8.0 0.07 0.015 0.3402 0.044 0.484 0.0250 0.074 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.3402 0.037 0.420 0.0250 0.073 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.3402 0.030 0.339 0.0250 0.067 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.3402 0.021 0.230 0.0250 0.049 0.042                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.3402 0.015 0.155 0.0250 0.034 0.028                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.3402 0.044 0.484 0.0125 0.074 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.3402 0.037 0.420 0.0125 0.073 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.3402 0.030 0.339 0.0125 0.067 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.


 2.0 0.07 0.015 0.3402 0.021 0.230 0.0125 0.049 0.054 0.021  0.23 4.133 0.045 0.054  0.008  0.072  0.071 -0.000 1.971 1.953

 1.0 0.07 0.015 0.3402 0.015 0.155 0.0125 0.034 0.034 0.015  0.15 1.684 0.034 0.034  0.000  0.047  0.047 -0.000 0.787 1.527

 8.0 0.07 0.015 0.3402 0.044 0.484 0.0100 0.074 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.3402 0.037 0.420 0.0100 0.073 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.3402 0.030 0.339 0.0100 0.067 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.3402 0.021 0.230 0.0100 0.049 0.059 0.022  0.23 4.133 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 1.542

 1.0 0.07 0.015 0.3402 0.015 0.155 0.0100 0.034 0.037 0.015  0.15 1.604 0.032 0.037  0.005  0.048  0.048 -0.000 0.793 1.324

 8.0 0.07 0.015 0.3402 0.044 0.484 0.0050 0.074 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.3402 0.037 0.420 0.0050 0.073 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.3402 0.030 0.339 0.0050 0.067 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.3402 0.021 0.230 0.0050 0.049 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 1.0 0.07 0.015 0.3402 0.015 0.155 0.0050 0.034 0.045 0.015  0.15 1.684 0.025 0.045  0.020  0.055  0.052 -0.003 0.696 0.916
 COMMON DATA  APPROACH PIPE DATA                                  TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC      HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH   ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.   ENERGY (SIN)    M.      M.   DEPTH ENERGY F.M  DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F.M.  POS.
                                 M.                          M.     M.    N.    M.     M.     M.      M.    M.      M.    N.    M.

8.0 0.07 0.015 0.5000 0.039 0.628 0.0250 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.5000 0.033 0.543 0.0250 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.5000 0.027 0.436 0.0250 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.5000 0.019 0.294 0.0250 0.049 0.042                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.07 0.015 0.5000 0.013 0.197 0.0250 0.034 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.07 0.015 0.5000 0.039 0.628 0.0125 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.5000 0.033 0.543 0.0125 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.5000 0.027 0.436 0.0125 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.5000 0.019 0.294 0.0125 0.049 0.054 0.019  0.29 4.696 0.045 0.054  0.008  0.072  0.071 -0.003 1.971 2.039

1.0 0.07 0.015 0.5000 0.013 0.197 0.0125 0.034 0.034 0.013  0.19 1.878 0.034 0.034  0.003  0.047  0.047 -0.000 0.787 1.717

8.0 0.07 0.015 0.5000 0.039 0.628 0.0100 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.5000 0.033 0.543 0.0100 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.5000 0.027 0.436 0.0100 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.5000 0.019 0.294 0.0100 0.049 0.059 0.019  0.29 4.696 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 1.597


1.0 0.07 0.015 0.5000 0.013 0.197 0.0100 0.034 0.037 0.013  0.19 1.878 0.032 0.037  0.005  0.048  0.048 -0.006 0.793 1.415

8.0 0.07 0.015 0.5000 0.039 0.628 0.0050 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.5000 0.033 0.543 0.0050 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.5000 0.027 0.436 0.0050 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.5000 0.019 0.294 0.0050 0.049 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

1.0 0.07 0.015 0.5000 0.013 0.197 0.0050 0.034 0.045 0.013  0.19 1.878 0.025 0.045  0.020  0.055  0.052 -0.003 0.896 0.906
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 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE   HN  TERM.  SLOPE   HC     HN  ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)   M.  ENERGY (SIN)   M.     M.  DEPTH ENERGY F.M  DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F.M.  POS.
                            M.                        M.    M.     N.   M.     M.    M.      M.     M.      M.    N.    M.

8.0 0.07 0.015 0.7070 0.036 0.799 0.0250 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.7070 0.030 0.686 0.0250 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.7070 0.024 0.551 0.0250 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.7070 0.017 0.370 0.0250 0.049 0.042                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.07 0.015 0.7070 0.012 0.247 0.0250 0.034 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.07 0.015 0.7070 0.036 0.799 0.0125 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.7070 0.030 0.686 0.0125 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.7070 0.024 0.551 0.0125 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.7070 0.017 0.370 0.0125 0.049 0.054 0.017  0.36 5.264 0.045 0.054  0.008  0.072  0.071 -0.000 1.971 2.155

1.0 0.07 0.015 0.7070 0.012 0.247 0.0125 0.034 0.034 0.012  0.24 2.120 0.034 0.034  0.000  0.047  0.047 -0.000 0.787 1.335

8.0 0.07 0.015 0.7070 0.036 0.799 0.0100 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.7070 0.030 0.686 0.0100 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.7070 0.024 0.551 0.0100 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.7070 0.017 0.370 0.0100 0.049 0.059 0.017  0.36 5.264 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 1.320

1.0 0.07 0.015 0.7070 0.012 0.247 0.0100 0.034 0.037 0.012  0.24 2.120 0.032 0.037  0.005  0.048  0.048 -0.000 0.793 1.335

8.0 0.07 0.015 0.7070 0.036 0.799 0.0050 0.074 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 0.7070 0.030 0.686 0.0050 0.073 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 0.7070 0.024 0.551 0.0050 0.067 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.7070 0.017 0.370 0.0050 0.049 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.


1.0 0.07 0.015 0.7070 0.012 0.247 0.0050 0.034 0.045 0.012  0.24 2.120 0.025 0.045  0.020  0.055  0.052 -0.003 0.696 0.933
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```
  COMMON DATA  APPROACH PIPE DATA                        TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN    TERM.   SLOPE    HC     HN    ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH   ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.    COEFF  (SIN)    M.    ENERGY  (SIN)    M.     M.    DEPTH ENERGY F+M  DEPTH DEPTH  CHANGE  UPJUMP DOWN   CHANGE F+M.  POS.
                                   M.                            M.    M.    N.     M.    M.     M.      M.     M.     M.     N.    M.

 8.0 0.07 0.015 0.8660 0.034 0.921 0.0250 0.074 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.8660 0.029 0.791 0.0250 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.8660 0.023 0.631 0.0250 0.067 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.8660 0.016 0.424 0.0250 0.049 0.042             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.8660 0.012 0.283 0.0250 0.034 0.028             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.8660 0.034 0.921 0.0125 0.074 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.8660 0.029 0.791 0.0125 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.8660 0.023 0.631 0.0125 0.067 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.8660 0.016 0.424 0.0125 0.049 0.054 0.016  0.41 5.598 0.045 0.054  0.008  0.072  0.071 -0.000 1.971 2.228

 1.0 0.07 0.015 0.8660 0.012 0.283 0.0125 0.034 0.034 0.012  0.28 2.315 0.034 0.034  0.000  0.047  0.047 -0.000 0.787 1.864

 8.0 0.07 0.015 0.8660 0.034 0.921 0.0100 0.074 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.8660 0.029 0.791 0.0100 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.8660 0.023 0.631 0.0100 0.067 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.8660 0.016 0.424 0.0100 0.049 0.059 0.016  0.41 5.598 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 1.883

 1.0 0.07 0.015 0.8660 0.012 0.283 0.0100 0.034 0.037 0.012  0.28 2.315 0.032 0.037  0.005  0.048  0.048 -0.000 0.793 1.564

 8.0 0.07 0.015 0.8660 0.034 0.921 0.0050 0.074 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.07 0.015 0.8660 0.029 0.791 0.0050 0.073 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.07 0.015 0.8660 0.023 0.631 0.0050 0.067 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.8660 0.016 0.424 0.0050 0.049 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 1.0 0.07 0.015 0.8660 0.012 0.283 0.0050 0.034 0.045 0.012  0.28 2.315 0.025 0.045  0.020  0.055  0.052 -0.003 0.896 1.352
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```
  COMMON DATA  APPROACH PIPE DATA                     TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLUPE    HN  TERM.  SLOPE    HC    HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.    M.  DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                         M.    M.    N.    M.     M.     M.     M.     M.     M.    N.    M.

8.0 0.07 0.015 1.0000 0.032 1.018 0.0250 0.074 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 1.0000 0.028 0.871 0.0250 0.073 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 1.0000 0.022 0.696 0.0250 0.067 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 1.0000 0.016 0.468 0.0250 0.049 0.042              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.



1.0 0.07 0.015 1.0000 0.011 0.310 0.0250 0.034 0.028              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.07 0.015 1.0000 0.032 1.018 0.0125 0.074 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 1.0000 0.028 0.871 0.0125 0.073 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 1.0000 0.022 0.696 0.0125 0.067 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 1.0000 0.016 0.468 0.0125 0.049 0.054 0.016  0.46 5.974 0.045 0.054  0.008  0.072  0.071 -0.000 1.971 2.293

1.0 0.07 0.015 1.0000 0.011 0.310 0.0125 0.034 0.034 0.011  0.31 2.425 0.034 0.034  0.000  0.047  0.047 -0.000 0.767 1.393

8.0 0.07 0.015 1.0000 0.032 1.018 0.0100 0.074 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 1.0000 0.028 0.871 0.0100 0.073 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 1.0000 0.022 0.696 0.0100 0.067 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 1.0000 0.016 0.468 0.0100 0.049 0.059 0.016  0.46 5.974 0.041 0.059  0.018  0.075  0.074 -0.001 2.049 1.945

1.0 0.07 0.015 1.0000 0.011 0.310 0.0100 0.034 0.037 0.011  0.31 2.425 0.032 0.037  0.005  0.048  0.048 -0.000 0.793 1.593

8.0 0.07 0.015 1.0000 0.032 1.018 0.0050 0.074 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.07 0.015 1.0000 0.028 0.871 0.0050 0.073 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.07 0.015 1.0000 0.022 0.696 0.0050 0.067 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 1.0000 0.016 0.468 0.0050 0.049 0.075              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

1.0 0.07 0.015 1.0000 0.011 0.310 0.0050 0.034 0.045 0.011  0.31 2.425 0.025 0.045  0.020  0.055  0.052 -0.003 0.696 1.081
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APPENDIX 2

JUMP LOCATION IN A 0.10 m DIAMETER PIPE, MANNING COEFFICIENT 0.015, AT SLOPES 1/40, 1/80, 1/100, 1/200

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 COMMON DATA  APPROACH PIPE DATA                            TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE    MN  TERM.  SLOPE    HC     MN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M   DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                              M.                          M.    M.    M.     M.    M.     M.

8.0 0.10 0.015 0.0349 0.078 0.153 0.0250 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0349 0.063 0.131 0.0250 0.079 0.071                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.0349 0.049 0.105 0.0250 0.065 0.054                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.0349 0.033 0.072 0.0250 0.045 0.036                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.0349 0.023 0.050 0.0250 0.031 0.025                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.0349 0.078 0.153 0.0125 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0349 0.063 0.131 0.0125 0.079 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.0349 0.049 0.105 0.0125 0.065 0.068 0.049  0.10 4.960 0.062 0.068  0.005  0.093  0.093 -0.000 4.477 1.313

2.0 0.10 0.015 0.0349 0.033 0.072 0.0125 0.045 0.044                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.0349 0.023 0.050 0.0125 0.031 0.030                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.0349 0.078 0.153 0.0100 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0349 0.063 0.131 0.0100 0.079 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.0349 0.049 0.105 0.0100 0.065 0.074 0.049  0.10 4.960 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 0.547

2.0 0.10 0.015 0.0349 0.033 0.072 0.0100 0.045 0.047 0.033  0.07 2.048 0.043 0.047  0.003  0.062  0.062 -0.000 1.808 0.778

1.0 0.10 0.015 0.0349 0.023 0.050 0.0100 0.031 0.032 0.023  0.05 0.844 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 0.585

8.0 0.10 0.015 0.0349 0.078 0.153 0.0050 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0349 0.063 0.131 0.0050 0.079 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.0349 0.049 0.105 0.0050 0.065 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.


2.0 0.10 0.015 0.0349 0.033 0.072 0.0050 0.045 0.058 0.033  0.07 2.048 0.035 0.058  0.023  0.069  0.067 -0.003 1.994 0.385

1.0 0.10 0.015 0.0349 0.023 0.050 0.0050 0.031 0.039 0.023  0.05 0.844 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 0.125
```

```
 COMMON DATA  APPROACH PIPE DATA                            TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE    HM   TERM.  SLOPE    HC     HM   ENTRY ENTRY ENTRY UPJUMP DOWN   DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M   DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  DIS.
                                M.                          M.    M.    M.    M.     M.     M.

8.0 0.10 0.015 0.0698 0.060 0.194 0.0250 0.089 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.050 0.167 0.0250 0.079 0.071             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.0698 0.040 0.134 0.0250 0.065 0.054             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.0698 0.028 0.092 0.0250 0.045 0.036             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.0698 0.020 0.063 0.0250 0.031 0.025             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.0698 0.060 0.194 0.0125 0.089 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.050 0.167 0.0125 0.079 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.0698 0.040 0.134 0.0125 0.065 0.068 0.043  0.13 5.860 0.062 0.063  0.005  0.093  0.093 -0.000 4.477 1.733

2.0 0.10 0.015 0.0698 0.028 0.092 0.0125 0.045 0.044             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.0698 0.020 0.063 0.0125 0.031 0.030             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.0698 0.060 0.194 0.0100 0.089 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.050 0.167 0.0100 0.079 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.0698 0.040 0.134 0.0100 0.065 0.074 0.043  0.13 5.860 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 1.252

2.0 0.10 0.015 0.0698 0.028 0.092 0.0100 0.045 0.047 0.023  0.09 2.425 0.044 0.047  0.003  0.062  0.062 -0.000 1.808 1.275

1.0 0.10 0.015 0.0698 0.020 0.063 0.0100 0.031 0.032 0.020  0.06 0.984 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 0.934

8.0 0.10 0.015 0.0698 0.060 0.194 0.0050 0.089 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.050 0.167 0.0050 0.079 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.0698 0.040 0.134 0.0050 0.065 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.10 0.015 0.0698 0.028 0.092 0.0050 0.045 0.058 0.023  0.09 2.425 0.035 0.058  0.023  0.069  0.067 -0.003 1.994 0.523

1.0 0.10 0.015 0.0698 0.020 0.063 0.0050 0.031 0.039 0.020  0.06 0.984 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 0.335
```

```
COMMON DATA  APPROACH PIPE DATA                                 TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN    TERM.   SLOPE    HC     HN   ENTRY  ENTRY  ENTRY UPJUMP  DOWN   DEPTH   ENERGY  ENERGY  ENERGY  JUMP  JUMP
L/S   M.    COEFF  (SIN)    M.   ENERGY  (SIN)     M.     M.   DEPTH  ENERGY F+M    DEPTH  DEPTH  CHANGE  UPJUMP  DOWN    CHANGE  F+M.  POS.
                                   M.                            M.     M.     N.      M.     M.      M.

8.0 0.10 0.015 0.1045 0.053 0.235 0.0250 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.045 0.202 0.0250 0.079 0.071                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.1045 0.036 0.163 0.0250 0.065 0.054                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.1045 0.025 0.110 0.0250 0.045 0.036                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.1045 0.018 0.075 0.0250 0.031 0.025                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.1045 0.053 0.235 0.0125 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.045 0.202 0.0125 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.1045 0.036 0.163 0.0125 0.065 0.068 0.036  0.16 6.659 0.062 0.053  0.005  0.093  0.093 -0.003 4.477 2.133

2.0 0.10 0.015 0.1045 0.025 0.110 0.0125 0.045 0.044                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.1045 0.018 0.075 0.0125 0.031 0.030                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.1045 0.053 0.235 0.0100 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.045 0.202 0.0100 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.1045 0.036 0.163 0.0100 0.065 0.074 0.036  0.16 6.659 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 1.555

2.0 0.10 0.015 0.1045 0.025 0.110 0.0100 0.045 0.047 0.025  0.11 2.695 0.044 0.047  0.003  0.062  0.062 -0.003 1.808 1.536

1.0 0.10 0.015 0.1045 0.018 0.075 0.0100 0.031 0.032 0.018  0.07 1.109 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.373

8.0 0.10 0.015 0.1045 0.053 0.235 0.0050 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.045 0.202 0.0050 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.1045 0.036 0.163 0.0050 0.065 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.10 0.015 0.1045 0.025 0.110 0.0050 0.045 0.058 0.025  0.11 2.695 0.035 0.058  0.023  0.069  0.067 -0.003 1.994 0.735

1.0 0.10 0.015 0.1045 0.018 0.075 0.0050 0.031 0.039 0.018  0.07 1.109 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 0.553
```

```
  COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN  TERM.  SLOPE    HC     HN   ENTRY  ENTRY  ENTRY UPJUMP DOWN   DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)   M.  ENERGY (SIN)    M.     M.   DEPTH  ENERGY F.N.   DEPTH DEPTH  CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                               M.                          M.     M.     N.     M.    M.     M.

8.0 0.10 0.015 0.1736 0.046 0.312 0.0250 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1736 0.039 0.267 0.0250 0.079 0.071                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.1736 0.031 0.214 0.0250 0.065 0.054                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.



2.0 0.10 0.015 0.1736 0.022 0.145 0.0250 0.045 0.036                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.1736 0.016 0.097 0.0250 0.031 0.025                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.1736 0.046 0.312 0.0125 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1736 0.039 0.267 0.0125 0.079 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.1736 0.031 0.214 0.0125 0.065 0.068 0.031  0.21 7.818 0.062 0.068  0.005  0.093  0.093 -0.000 4.477 2.518

2.0 0.10 0.015 0.1736 0.022 0.145 0.0125 0.045 0.044                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.1736 0.016 0.097 0.0125 0.031 0.030                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.1736 0.046 0.312 0.0100 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1736 0.039 0.267 0.0100 0.079 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.1736 0.031 0.214 0.0100 0.065 0.074 0.031  0.21 7.818 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 2.079

2.0 0.10 0.015 0.1736 0.022 0.145 0.0100 0.045 0.047 0.022  0.14 3.143 0.043 0.047  0.003  0.062  0.062 -0.000 1.608 1.775

1.0 0.10 0.015 0.1736 0.016 0.097 0.0100 0.031 0.032 0.016  0.09 1.285 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.244

8.0 0.10 0.015 0.1736 0.046 0.312 0.0050 0.089 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1736 0.039 0.267 0.0050 0.079 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.1736 0.031 0.214 0.0050 0.065 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.10 0.015 0.1736 0.022 0.145 0.0050 0.045 0.058 0.022  0.14 3.143 0.035 0.058  0.023  0.069  0.067 -0.003 1.994 0.995

1.0 0.10 0.015 0.1736 0.016 0.097 0.0050 0.031 0.039 0.016  0.09 1.285 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 0.724
```

```
 COMMON DATA  APPROACH PIPE DATA                           TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S   M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M   DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                  M.                          M.     M.   M.     M.    M.     M.

 8.0 0.10 0.015 0.3402 0.038 0.474 0.0250 0.089 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.3402 0.033 0.404 0.0250 0.079 0.071                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.3402 0.026 0.322 0.0250 0.065 0.054                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.3402 0.019 0.216 0.0250 0.045 0.036                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.3402 0.013 0.144 0.0250 0.031 0.025                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.3402 0.038 0.474 0.0125 0.089 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.3402 0.033 0.404 0.0125 0.079 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.3402 0.026 0.322 0.0125 0.065 0.068 0.026  0.32 9.778 0.062 0.068  0.005  0.093  0.093 -0.000 4.477 3.331



 2.0 0.10 0.015 0.3402 0.019 0.216 0.0125 0.045 0.044                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.3402 0.013 0.144 0.0125 0.031 0.030                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.3402 0.038 0.474 0.0100 0.089 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.3402 0.033 0.404 0.0100 0.079 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.3402 0.026 0.322 0.0100 0.065 0.074 0.026  0.32 9.778 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 2.538

 2.0 0.10 0.015 0.3402 0.019 0.216 0.0100 0.045 0.047 0.019  0.21 3.929 0.043 0.047  0.003  0.062  0.062 -0.000 1.808 2.088

 1.0 0.10 0.015 0.3402 0.013 0.144 0.0100 0.031 0.032 0.013  0.14 1.612 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.456

 8.0 0.10 0.015 0.3402 0.038 0.474 0.0050 0.089 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.3402 0.033 0.404 0.0050 0.079 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.3402 0.026 0.322 0.0050 0.065 0.100                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.10 0.015 0.3402 0.019 0.216 0.0050 0.045 0.058 0.019  0.21 3.929 0.035 0.058  0.023  0.069  0.067 -0.003 1.994 1.332

 1.0 0.10 0.015 0.3402 0.013 0.144 0.0050 0.031 0.039 0.013  0.14 1.612 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 0.332
 COMMON DATA  APPROACH PIPE DATA                                       TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN    TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)   M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M   DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                M.                          M.    M.    N.    M.    M.     M.

 8.0 0.10 0.015 0.5000 0.034 0.611 0.0250 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.029 0.521 0.0250 0.079 0.071                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.5000 0.024 0.413 0.0250 0.065 0.054                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.5000 0.017 0.276 0.0250 0.045 0.036                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.5000 0.012 0.183 0.0250 0.031 0.025                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.5000 0.034 0.611 0.0125 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.029 0.521 0.0125 0.079 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.5000 0.024 0.413 0.0125 0.065 0.068 0.024  0.4111.179 0.062 0.068  0.005  0.093  0.093 -0.003 4.477 3.310

 2.0 0.10 0.015 0.5000 0.017 0.276 0.0125 0.045 0.044                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.5000 0.012 0.183 0.0125 0.031 0.030                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.5000 0.034 0.611 0.0100 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.029 0.521 0.0100 0.079 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.5000 0.024 0.413 0.0100 0.065 0.074 0.024  0.4111.179 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 2.755

 2.0 0.10 0.015 0.5000 0.017 0.276 0.0100 0.045 0.047 0.017  0.26 4.398 0.044 0.047  0.003  0.062  0.062 -0.003 1.808 2.222


 1.0 0.10 0.015 0.5000 0.012 0.183 0.0100 0.031 0.032 0.012  0.17 1.793 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.537

 8.0 0.10 0.015 0.5000 0.034 0.611 0.0050 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.029 0.521 0.0050 0.079 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.5000 0.024 0.413 0.0050 0.065 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.10 0.015 0.5000 0.017 0.276 0.0050 0.045 0.058 0.017  0.26 4.398 0.035 0.058  0.023  0.070  0.067 -0.003 1.994 1.435

 1.0 0.10 0.015 0.5000 0.012 0.183 0.0050 0.031 0.039 0.012  0.17 1.793 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 1.313
 COMMON DATA  APPROACH PIPE DATA                                 TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.M   DEPTH DEPTH CHANGE UPJUMP DOWN  CHANGE F.M.  POS.
                                M.                          M.    M.    M.     M.    M.     M.

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0250 0.089 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0250 0.079 0.071                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0250 0.065 0.054                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0250 0.045 0.036                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.7070 0.011 0.229 0.0250 0.031 0.025                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0125 0.089 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0125 0.079 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0125 0.065 0.068 0.022  0.4912.216 0.062 0.063  0.005  0.093  0.093 -0.000 4.477 3.443

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0125 0.045 0.044                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.7070 0.011 0.229 0.0125 0.031 0.030                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0100 0.089 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0100 0.079 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0100 0.065 0.074 0.022  0.4912.216 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 2.936

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0100 0.045 0.047 0.016  0.33 4.983 0.044 0.047  0.003  0.062  0.062 -0.000 1.808 2.356

 1.0 0.10 0.015 0.7070 0.011 0.229 0.0100 0.031 0.032 0.011  0.21 2.016 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.621

 8.0 0.10 0.015 0.7070 0.031 0.772 0.0050 0.089 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.7070 0.027 0.655 0.0050 0.079 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.7070 0.022 0.518 0.0050 0.065 0.100                    FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.10 0.015 0.7070 0.016 0.345 0.0050 0.045 0.058 0.016  0.33 4.983 0.035 0.058  0.023  0.070  0.067 -0.003 1.994 1.555



 1.0 0.10 0.015 0.7070 0.011 0.229 0.0050 0.031 0.039 0.011  0.21 2.016 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 1.335
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COMMON DATA  APPROACH PIPE DATA                       TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN   DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N.  DEPTH DEPTH  CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                           M.    M.    N.    M.     M.     M.

8.0 0.10 0.015 0.8660 0.030 0.883 0.0250 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.8660 0.026 0.753 0.0250 0.079 0.071                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.8660 0.021 0.593 0.0250 0.065 0.054                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.8660 0.015 0.395 0.0250 0.045 0.036                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.8660 0.011 0.262 0.0250 0.031 0.025                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.8660 0.030 0.883 0.0125 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.8660 0.026 0.753 0.0125 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.8660 0.021 0.593 0.0125 0.065 0.068 0.021  0.5913.446 0.062 0.063  0.005  0.093  0.093 -0.000 4.477 3.535

2.0 0.10 0.015 0.8660 0.015 0.395 0.0125 0.045 0.044                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.8660 0.011 0.262 0.0125 0.031 0.030                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.8660 0.030 0.883 0.0100 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.8660 0.026 0.753 0.0100 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.8660 0.021 0.593 0.0100 0.065 0.074 0.021  0.5913.446 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 3.041

2.0 0.10 0.015 0.8660 0.015 0.395 0.0100 0.045 0.047 0.015  0.39 5.459 0.044 0.047  0.003  0.062  0.062 -0.003 1.808 2.443

1.0 0.10 0.015 0.8660 0.011 0.262 0.0100 0.031 0.032 0.011  0.24 2.148 0.031 0.032  0.001  0.043  0.043 -0.003 0.743 1.651

8.0 0.10 0.015 0.8660 0.030 0.883 0.0050 0.089 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.8660 0.026 0.753 0.0050 0.079 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.8660 0.021 0.593 0.0050 0.065 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.10 0.015 0.8660 0.015 0.395 0.0050 0.045 0.058 0.015  0.39 5.459 0.035 0.058  0.023  0.070  0.067 -0.003 1.994 1.653

1.0 0.10 0.015 0.8660 0.011 0.262 0.0050 0.031 0.039 0.011  0.24 2.148 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 1.135
```

```
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN   DEPTH   ENERGY ENERGY ENERGY JUMP  JUMP


L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F+M    DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                             M.                          M.     M.    N.     M.     M.     M.

8.0 0.10 0.015 0.9659 0.029 0.952 0.0250 0.089 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
6.0 0.10 0.015 0.9659 0.025 0.810 0.0250 0.079 0.071                      JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
4.0 0.10 0.015 0.9659 0.020 0.639 0.0250 0.065 0.054                      JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
2.0 0.10 0.015 0.9659 0.015 0.426 0.0250 0.045 0.036                      JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
1.0 0.10 0.015 0.9659 0.010 0.282 0.0250 0.031 0.025                      JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
8.0 0.10 0.015 0.9659 0.029 0.952 0.0125 0.089 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
6.0 0.10 0.015 0.9659 0.025 0.810 0.0125 0.079 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
4.0 0.10 0.015 0.9659 0.020 0.639 0.0125 0.065 0.068 0.020  0.6313.907 0.062 0.068  0.005  0.093  0.093 -0.000 4.477 3.531
2.0 0.10 0.015 0.9659 0.015 0.426 0.0125 0.045 0.044                      JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
1.0 0.10 0.015 0.9659 0.010 0.282 0.0125 0.031 0.030                      JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
8.0 0.10 0.015 0.9659 0.029 0.952 0.0100 0.089 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
6.0 0.10 0.015 0.9659 0.025 0.810 0.0100 0.079 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
4.0 0.10 0.015 0.9659 0.020 0.639 0.0100 0.065 0.074 0.020  0.6313.907 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 3.337
2.0 0.10 0.015 0.9659 0.015 0.426 0.0100 0.045 0.047 0.015  0.39 5.459 0.044 0.047  0.003  0.062  0.062 -0.000 1.808 2.443
1.0 0.10 0.015 0.9659 0.010 0.282 0.0100 0.031 0.032 0.010  0.27 2.296 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.731
8.0 0.10 0.015 0.9659 0.029 0.952 0.0050 0.089 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
6.0 0.10 0.015 0.9659 0.025 0.810 0.0050 0.079 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
4.0 0.10 0.015 0.9659 0.020 0.639 0.0050 0.065 0.100                      FULL BORE FLOW ESTABLISHED IN TEST PIPE.
2.0 0.10 0.015 0.9659 0.015 0.426 0.0050 0.045 0.058 0.015  0.39 5.459 0.035 0.058  0.023  0.070  0.067 -0.003 1.994 1.650
1.0 0.10 0.015 0.9659 0.010 0.282 0.0050 0.031 0.039 0.010  0.27 2.296 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 1.175
```

```
 COMMON DATA  APPROACH PIPE DATA                           TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE   HN   TERM.  SLOPE   HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)   M.  ENERGY (SIN)   M.     M.   DEPTH ENERGY F+M   DEPTH DEPTH CHANGE UPJUMP DOWN  CHANGE F+M.  POS.
                               M.                        M.    M.    M.     M.    M.     M.

 8.0 0.10 0.015 1.0000 0.029 0.978 0.0250 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 1.0000 0.025 0.827 0.0250 0.079 0.071                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 1.0000 0.020 0.654 0.0250 0.065 0.054                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 1.0000 0.014 0.436 0.0250 0.045 0.036                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.



 1.0 0.10 0.015 1.0000 0.010 0.288 0.0250 0.031 0.025                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 1.0000 0.029 0.978 0.0125 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 1.0000 0.025 0.827 0.0125 0.079 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 1.0000 0.020 0.654 0.0125 0.065 0.068 0.020  0.6313.907 0.062 0.068  0.005  0.093  0.093 -0.000 4.477 3.631

 2.0 0.10 0.015 1.0000 0.014 0.436 0.0125 0.045 0.044                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 1.0000 0.010 0.288 0.0125 0.031 0.030                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 1.0000 0.029 0.978 0.0100 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 1.0000 0.025 0.827 0.0100 0.079 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 1.0000 0.020 0.654 0.0100 0.065 0.074 0.020  0.6313.907 0.057 0.074  0.017  0.095  0.095 -0.000 4.579 3.087

 2.0 0.10 0.015 1.0000 0.014 0.436 0.0100 0.045 0.047 0.014  0.43 5.728 0.044 0.047  0.003  0.062  0.062 -0.000 1.808 2.483

 1.0 0.10 0.015 1.0000 0.010 0.288 0.0100 0.031 0.032 0.010  0.27 2.296 0.031 0.032  0.001  0.043  0.043 -0.000 0.743 1.731

 8.0 0.10 0.015 1.0000 0.029 0.978 0.0050 0.089 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 1.0000 0.025 0.827 0.0050 0.079 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 1.0000 0.020 0.654 0.0050 0.065 0.100                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.10 0.015 1.0000 0.014 0.436 0.0050 0.045 0.058 0.014  0.43 5.728 0.035 0.058  0.023  0.069  0.067 -0.003 1.994 1.691

 1.0 0.10 0.015 1.0000 0.010 0.288 0.0050 0.031 0.039 0.010  0.27 2.296 0.025 0.039  0.013  0.046  0.045 -0.001 0.799 1.175
```

APPENDIX 3

JUMP LOCATION IN A 0.15 m DIAMETER PIPE, MANNING COEFFICIENT 0.015, AT SLOPES 1/40, 1/80, 1/100, 1/150, 1/200, 1/300, 1/400, 1/600

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PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                                    TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                               M.                         M.    M.    N.    M.     M.    M.      M.    M.      M.    N.    M.

 8.0 0.15 0.015 0.0349 0.059 0.138 0.0250 0.082 0.064                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 0.0349 0.050 0.118 0.0250 0.071 0.055                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 0.0349 0.041 0.095 0.0250 0.057 0.044                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.0349 0.029 0.065 0.0250 0.040 0.031                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.0349 0.021 0.044 0.0250 0.028 0.022                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.0349 0.059 0.138 0.0125 0.082 0.079                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 0.0349 0.050 0.118 0.0125 0.071 0.067                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 0.0349 0.041 0.095 0.0125 0.057 0.053                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.0349 0.029 0.065 0.0125 0.040 0.037                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.0349 0.021 0.044 0.0125 0.028 0.026                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.0349 0.059 0.138 0.0100 0.082 0.084 0.059  0.1411.436 0.080 0.084  0.004  0.115  0.115  0.000 9.885 1.972

 6.0 0.15 0.015 0.0349 0.050 0.118 0.0100 0.071 0.071 0.051  0.12 7.894 0.071 0.071  0.000  0.098  0.098  0.000 6.795 2.033

 4.0 0.15 0.015 0.0349 0.041 0.095 0.0100 0.057 0.057                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.0349 0.029 0.065 0.0100 0.040 0.039                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.0349 0.021 0.044 0.0100 0.028 0.028                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.0349 0.059 0.138 0.0066 0.082 0.096 0.059  0.1411.436 0.070 0.096  0.027  0.120  0.119 -0.00110.284 0.853

 6.0 0.15 0.015 0.0349 0.050 0.118 0.0066 0.071 0.080 0.051  0.12 7.894 0.062 0.080  0.018  0.101  0.100  0.000 6.973 0.927

 4.0 0.15 0.015 0.0349 0.041 0.095 0.0066 0.057 0.063 0.041  0.09 4.708 0.051 0.063  0.012  0.080  0.080  0.000 4.107 0.852

 2.0 0.15 0.015 0.0349 0.029 0.065 0.0066 0.040 0.044 0.029  0.06 1.932 0.036 0.044  0.007  0.055  0.055  0.000 1.692 0.571

 1.0 0.15 0.015 0.0349 0.021 0.044 0.0066 0.024 0.031 0.021  0.04 0.791 0.025 0.031  0.006  0.038  0.038  0.000 0.706 0.321
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA.  MANN. SLOPE    HN  TERM.  SLOPE    HC     HN   ENTRY ENTRY  ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP   JUMP
 L/S   M.    COEFF (SIN)    M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M   DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.   POS.
                                 M.                          M.    M.     N.    M.     M.     M.        M.     M.       M.     N.     M.


  8.0 0.15 0.015 0.0349 0.059 0.138 0.0050 0.082 0.107 0.059  0.1411.436 0.062 0.107  0.045  0.130  0.125 -0.00511.008 0.251

  6.0 0.15 0.015 0.0349 0.050 0.118 0.0050 0.071 0.087 0.051  0.12 7.894 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 0.463

  4.0 0.15 0.015 0.0349 0.041 0.095 0.0050 0.057 0.069 0.041  0.09 4.708 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 0.498

  2.0 0.15 0.015 0.0349 0.029 0.065 0.0050 0.040 0.047 0.029  0.06 1.932 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 0.345

  1.0 0.15 0.015 0.0349 0.021 0.044 0.0050 0.028 0.033 0.021  0.04 0.791 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 0.182

  8.0 0.15 0.015 0.0349 0.059 0.138 0.0050 0.082 0.132                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  6.0 0.15 0.015 0.0349 0.050 0.118 0.0050 0.071 0.101                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  4.0 0.15 0.015 0.0349 0.041 0.095 0.0050 0.057 0.077                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  2.0 0.15 0.015 0.0349 0.029 0.065 0.0050 0.040 0.053 0.029  0.06 1.932 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 0.041

  1.0 0.15 0.015 0.0349 0.021 0.044 0.0050 0.028 0.037                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  8.0 0.15 0.015 0.0349 0.059 0.138 0.0025 0.082 0.150                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

  6.0 0.15 0.015 0.0349 0.050 0.118 0.0025 0.071 0.112                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  4.0 0.15 0.015 0.0349 0.041 0.095 0.0025 0.057 0.084                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  2.0 0.15 0.015 0.0349 0.029 0.065 0.0025 0.040 0.057                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  1.0 0.15 0.015 0.0349 0.021 0.044 0.0025 0.028 0.039                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  8.0 0.15 0.015 0.0349 0.059 0.138 0.0017 0.082 0.150                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

  6.0 0.15 0.015 0.0349 0.050 0.118 0.0017 0.071 0.150                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

  4.0 0.15 0.015 0.0349 0.041 0.095 0.0017 0.057 0.096                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  2.0 0.15 0.015 0.0349 0.029 0.065 0.0017 0.040 0.063                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

  1.0 0.15 0.015 0.0349 0.021 0.044 0.0017 0.028 0.044                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA.  MANN.  SLOPE    HN   TERM.   SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.    COEFF  (SIN)    M.   ENERGY  (SIN)    M.     M.   DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                M.                           M.    M.     N.   M.     M.    M.     M.     M.     M.     N.    M.

8.0 0.15 0.015 0.0698 0.049 0.180 0.0250 0.082 0.064                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

6.0 0.15 0.015 0.0698 0.042 0.153 0.0250 0.071 0.055                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

4.0 0.15 0.015 0.0698 0.034 0.122 0.0250 0.057 0.044                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

2.0 0.15 0.015 0.0698 0.024 0.083 0.0250 0.040 0.031                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

1.0 0.15 0.015 0.0698 0.017 0.056 0.0250 0.028 0.022                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

8.0 0.15 0.015 0.0698 0.049 0.180 0.0125 0.082 0.079                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

6.0 0.15 0.015 0.0698 0.042 0.153 0.0125 0.071 0.067                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

4.0 0.15 0.015 0.0698 0.034 0.122 0.0125 0.057 0.053                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

2.0 0.15 0.015 0.0698 0.024 0.083 0.0125 0.040 0.037                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

1.0 0.15 0.015 0.0698 0.017 0.056 0.0125 0.028 0.026                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

8.0 0.15 0.015 0.0698 0.049 0.180 0.0100 0.082 0.084 0.049  0.1813.607 0.080 0.084  0.004  0.115  0.115  0.000 9.685 3.033

6.0 0.15 0.015 0.0698 0.042 0.153 0.0100 0.071 0.071 0.043  0.15 9.388 0.071 0.071  0.000  0.098  0.098  0.000 6.795 2.913

4.0 0.15 0.015 0.0698 0.034 0.122 0.0100 0.057 0.057                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

2.0 0.15 0.015 0.0698 0.024 0.083 0.0100 0.040 0.039                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

1.0 0.15 0.015 0.0698 0.017 0.056 0.0100 0.028 0.028                  JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.

8.0 0.15 0.015 0.0698 0.049 0.180 0.0066 0.082 0.096 0.049  0.1813.607 0.070 0.096  0.027  0.120  0.119 -0.00110.284 1.835

6.0 0.15 0.015 0.0698 0.042 0.153 0.0066 0.071 0.080 0.043  0.15 9.388 0.062 0.080  0.018  0.101  0.100  0.000 6.973 1.734

4.0 0.15 0.015 0.0698 0.034 0.122 0.0066 0.057 0.063 0.034  0.12 5.636 0.051 0.063  0.012  0.080  0.080  0.000 4.107 1.513

2.0 0.15 0.015 0.0698 0.024 0.083 0.0066 0.040 0.044 0.025  0.08 2.285 0.036 0.044  0.007  0.055  0.055  0.000 1.692 0.988

1.0 0.15 0.015 0.0698 0.017 0.056 0.0066 0.028 0.031 0.018  0.05 0.918 0.025 0.031  0.006  0.038  0.038  0.000 0.706 0.576
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN    TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP   JUMP
L/S   M.    COEFF  (SIN)    M.   ENERGY  (SIN)    M.     M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.   POS.
                                   M.                           M.    M.    N.    M.     M.     M.      M.     M.      M.     N.     M.

 8.0 0.15 0.015 0.1045 0.044 0.219 0.0250 0.082 0.064                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0250 0.071 0.055                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 0.1045 0.031 0.148 0.0250 0.057 0.044                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0250 0.040 0.031                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0250 0.028 0.022                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.1045 0.044 0.219 0.0125 0.082 0.079                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0125 0.071 0.067                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 0.1045 0.031 0.148 0.0125 0.057 0.053                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0125 0.040 0.037                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0125 0.028 0.026                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.1045 0.044 0.219 0.0100 0.082 0.084 0.044  0.2215.472 0.081 0.084  0.004  0.115  0.115  0.000 9.685 3.565

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0100 0.071 0.071 0.038  0.1810.681 0.071 0.071  0.000  0.098  0.098  0.000 6.795 3.388

 4.0 0.15 0.015 0.1045 0.031 0.148 0.0100 0.057 0.057                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0100 0.040 0.039                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0100 0.028 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.1045 0.044 0.219 0.0066 0.082 0.096 0.044  0.2215.472 0.070 0.096  0.027  0.120  0.119 -0.00110.284 2.338

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0066 0.071 0.080 0.038  0.1810.681 0.062 0.080  0.018  0.101  0.100  0.000 6.973 2.189

 4.0 0.15 0.015 0.1045 0.031 0.148 0.0066 0.057 0.063 0.031  0.14 6.271 0.052 0.063  0.012  0.080  0.080  0.000 4.107 1.810

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0066 0.040 0.044 0.022  0.10 2.555 0.036 0.044  0.007  0.055  0.055  0.000 1.692 1.199

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0066 0.028 0.031 0.016  0.06 1.015 0.025 0.031  0.006  0.038  0.038  0.000 0.706 0.737
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PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.



 COMMON DATA  APPROACH PIPE DATA                                  TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP   JUMP
 L/S   M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F*M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F*M.   POS.
                               M.                           M.    M.    N.    M.     M.    M.       M.   M.      M.    N.     M.


 8.0 0.15 0.015 0.0699 0.049 0.180 0.0050 0.082 0.107 0.049  0.1813.607 0.062 0.107  0.045  0.130  0.125 -0.00511.008 1.157
 6.0 0.15 0.015 0.0699 0.042 0.153 0.0050 0.071 0.087 0.043  0.15 9.388 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 1.239
 4.0 0.15 0.015 0.0699 0.034 0.122 0.0050 0.057 0.069 0.034  0.12 5.636 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 1.131
 2.0 0.15 0.015 0.0699 0.024 0.083 0.0050 0.040 0.047 0.025  0.08 2.285 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 0.745
 1.0 0.15 0.015 0.0699 0.017 0.056 0.0050 0.028 0.033 0.018  0.05 0.918 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 0.426
 8.0 0.15 0.015 0.0699 0.049 0.180 0.0050 0.082 0.132              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 6.0 0.15 0.015 0.0699 0.042 0.153 0.0050 0.071 0.101 0.043  0.15 9.388 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 0.517
 4.0 0.15 0.015 0.0699 0.034 0.122 0.0050 0.057 0.077 0.034  0.12 5.636 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 0.630
 2.0 0.15 0.015 0.0699 0.024 0.083 0.0050 0.040 0.053 0.025  0.08 2.285 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 0.441
 1.0 0.15 0.015 0.0699 0.017 0.056 0.0050 0.028 0.037 0.018  0.05 0.918 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.234
 8.0 0.15 0.015 0.0699 0.049 0.180 0.0025 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.15 0.015 0.0699 0.042 0.153 0.0025 0.071 0.112              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 4.0 0.15 0.015 0.0699 0.034 0.122 0.0025 0.057 0.084 0.034  0.12 5.636 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 0.250
 2.0 0.15 0.015 0.0699 0.024 0.083 0.0025 0.040 0.057 0.025  0.08 2.285 0.027 0.057  0.029  0.070  0.062 -0.006 2.670 0.239
 1.0 0.15 0.015 0.0699 0.017 0.056 0.0025 0.028 0.039 0.018  0.05 0.918 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.094
 8.0 0.15 0.015 0.0699 0.049 0.180 0.0017 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.15 0.015 0.0699 0.042 0.153 0.0017 0.071 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 4.0 0.15 0.015 0.0699 0.034 0.122 0.0017 0.057 0.096              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 2.0 0.15 0.015 0.0699 0.024 0.083 0.0017 0.040 0.063              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 1.0 0.15 0.015 0.0699 0.017 0.056 0.0017 0.028 0.044              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
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PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN   VERT.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)   M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN  CHANGE F+M.  POS.
                              M.                          M.    M.    N.    M.     M.     M.      M.    M.     M.    N.     M.


 8.0 0.15 0.015 0.1045 0.044 0.219 0.0050 0.082 0.107 0.044  0.2215.472 0.062 0.107  0.045  0.130  0.125 -0.00511.008 1.680

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0050 0.071 0.087 0.038  0.1810.681 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 1.686

 4.0 0.15 0.015 0.1045 0.031 0.148 0.0050 0.057 0.069 0.031  0.14 6.271 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 1.424

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0050 0.040 0.047 0.022  0.10 2.555 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 0.953

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0050 0.028 0.033 0.016  0.06 1.015 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 0.553

 8.0 0.15 0.015 0.1045 0.044 0.219 0.0050 0.082 0.132 0.044  0.2215.472 0.049 0.132  0.083  0.181  0.144 -0.03713.660 0.444

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0050 0.071 0.101 0.038  0.1810.681 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 0.956

 4.0 0.15 0.015 0.1045 0.031 0.148 0.0050 0.057 0.077 0.031  0.14 6.271 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 0.923

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0050 0.040 0.053 0.022  0.10 2.555 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 0.648

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0050 0.028 0.037 0.016  0.06 1.015 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.351

 8.0 0.15 0.015 0.1045 0.044 0.219 0.0025 0.082 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0025 0.071 0.112 0.038  0.1810.681 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 0.387

 4.0 0.15 0.015 0.1045 0.031 0.146 0.0025 0.057 0.084 0.031  0.14 6.271 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 0.534

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0025 0.040 0.057 0.022  0.10 2.555 0.027 0.057  0.029  0.070  0.062 -0.006 2.070 0.408

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0025 0.028 0.039 0.016  0.06 1.015 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.217

 8.0 0.15 0.015 0.1045 0.044 0.219 0.0017 0.082 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0017 0.071 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.15 0.015 0.1045 0.031 0.146 0.0017 0.057 0.096 0.031  0.14 6.271 0.032 0.096  0.064  0.141  0.101 -0.040 6.199 0.030

 2.0 0.15 0.015 0.1045 0.022 0.100 0.0017 0.040 0.063 0.022  0.10 2.555 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.119

 1.0 0.15 0.015 0.1045 0.016 0.067 0.0017 0.028 0.044 0.016  0.06 1.015 0.017 0.044  0.027  0.059  0.046 -0.013 0.964 0.035
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PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA   APPROACH PIPE DATA                           TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA.  MANN.  SLOPE    HN    TERM.  SLOPE    HC     HN    ENTRY  ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S   M.    COEFF  (SIN)    M.   ENERGY  (SIN)    M.     M.    DEPTH ENERGY F.N.  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                    M.                            M.     M.    N.    M.     M.     M.     M.     M.      M.    N.    M.

 8.0 0.15 0.015 0.1736 0.039 0.290 0.0250 0.082 0.064                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.1736 0.033 0.246 0.0250 0.071 0.055                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.1736 0.027 0.195 0.0250 0.057 0.044                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.1736 0.020 0.131 0.0250 0.040 0.031                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.1736 0.014 0.087 0.0250 0.028 0.022                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.1736 0.039 0.290 0.0125 0.082 0.079                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.1736 0.033 0.246 0.0125 0.071 0.067                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.1736 0.027 0.195 0.0125 0.057 0.053                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.1736 0.020 0.131 0.0125 0.040 0.037                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.1736 0.014 0.087 0.0125 0.028 0.026                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.1736 0.039 0.290 0.0100 0.082 0.084 0.039  0.2818.103 0.081 0.084  0.004  0.115  0.115  0.000 9.685 4.127
 6.0 0.15 0.015 0.1736 0.033 0.246 0.0100 0.071 0.071 0.034  0.2412.499 0.071 0.071  0.000  0.098  0.098  0.000 6.795 3.858
 4.0 0.15 0.015 0.1736 0.027 0.195 0.0100 0.057 0.057                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.1736 0.020 0.131 0.0100 0.040 0.039                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.1736 0.014 0.087 0.0100 0.028 0.028                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.1736 0.039 0.290 0.0066 0.082 0.096 0.039  0.2818.103 0.070 0.096  0.027  0.120  0.119 -0.00110.284 2.883
 6.0 0.15 0.015 0.1736 0.033 0.246 0.0066 0.071 0.080 0.034  0.2412.499 0.062 0.080  0.018  0.101  0.100 -0.001 6.973 2.653
 4.0 0.15 0.015 0.1736 0.027 0.195 0.0066 0.057 0.063 0.028  0.19 7.361 0.051 0.063  0.012  0.080  0.080  0.000 4.107 2.193
 2.0 0.15 0.015 0.1736 0.020 0.131 0.0066 0.040 0.044 0.020  0.12 2.919 0.036 0.044  0.007  0.055  0.055  0.000 1.692 1.412
 1.0 0.15 0.015 0.1736 0.014 0.087 0.0066 0.028 0.031 0.014  0.08 1.221 0.025 0.031  0.006  0.038  0.038  0.000 0.706 0.932
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```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                                      TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA.  MANN.  SLOPE    HN    TERM.  SLOPE     HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S   M.    COEFF  (SIN)    M.   ENERGY  (SIN)     M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                    M.                            M.     M.    N.     M.    M.     M.      M.    M.      M.    N.    M.

 8.0 0.15 0.015 0.1736 0.039 0.290 0.0050 0.082 0.107 0.039   0.2818.103 0.062 0.107  0.045  0.130  0.125 -0.00511.008 2.214

 6.0 0.15 0.015 0.1736 0.033 0.246 0.0050 0.071 0.087 0.034   0.2412.499 0.057 0.087  0.031  0.106  0.103 -0.002 7.513 2.140

 4.0 0.15 0.015 0.1736 0.027 0.195 0.0050 0.057 0.069 0.028   0.19 7.361 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 1.792

 2.0 0.15 0.015 0.1736 0.020 0.131 0.0050 0.040 0.047 0.020   0.12 2.919 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 1.151

 1.0 0.15 0.015 0.1736 0.014 0.087 0.0050 0.028 0.033 0.014   0.08 1.221 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 0.745

 8.0 0.15 0.015 0.1736 0.039 0.290 0.0050 0.082 0.132 0.039   0.2818.103 0.049 0.132  0.083  0.181  0.144 -0.03713.860 0.981

 6.0 0.15 0.015 0.1736 0.033 0.246 0.0050 0.071 0.101 0.034   0.2412.499 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 1.419

 4.0 0.15 0.015 0.1736 0.027 0.195 0.0050 0.057 0.077 0.028   0.19 7.361 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 1.292

 2.0 0.15 0.015 0.1736 0.020 0.131 0.0050 0.040 0.053 0.020   0.12 2.919 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 0.857

 1.0 0.15 0.015 0.1736 0.014 0.087 0.0050 0.028 0.037 0.014   0.08 1.221 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.553

 8.0 0.15 0.015 0.1736 0.039 0.290 0.0025 0.082 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.1736 0.033 0.246 0.0025 0.071 0.112 0.034   0.2412.499 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 0.835

 4.0 0.15 0.015 0.1736 0.027 0.195 0.0025 0.057 0.084 0.028   0.19 7.361 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 0.896

 2.0 0.15 0.015 0.1736 0.020 0.131 0.0025 0.040 0.057 0.020   0.12 2.919 0.027 0.057  0.029  0.070  0.062 -0.006 2.070 0.613

 1.0 0.15 0.015 0.1736 0.014 0.087 0.0025 0.028 0.039 0.014   0.08 1.221 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.436

 8.0 0.15 0.015 0.1736 0.039 0.290 0.0017 0.082 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.1736 0.033 0.246 0.0017 0.071 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.15 0.015 0.1736 0.027 0.195 0.0017 0.057 0.096 0.028   0.19 7.361 0.032 0.095  0.064  0.141  0.101 -0.040 6.199 0.389

 2.0 0.15 0.015 0.1736 0.020 0.131 0.0017 0.040 0.063 0.020   0.12 2.919 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.322

 1.0 0.15 0.015 0.1736 0.014 0.087 0.0017 0.028 0.044 0.014   0.08 1.221 0.017 0.044  0.027  0.059  0.046 -0.013 0.984 0.222
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```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                            TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE   HC    HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)   M.    M.  DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                              M.                         M.    M.   N.    M.     M.    M.      M.    M.     M.     N.    M.

 8.0 0.15 0.015 0.3402 0.033 0.437 0.0250 0.082 0.064              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0250 0.071 0.055              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0250 0.057 0.044              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0250 0.040 0.031              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0250 0.028 0.022              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.3402 0.033 0.437 0.0125 0.082 0.079              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0125 0.071 0.067              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0125 0.057 0.053              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0125 0.040 0.037              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0125 0.028 0.026              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.3402 0.033 0.437 0.0100 0.082 0.084 0.033  0.4322.584 0.081 0.084  0.003  0.115  0.115  0.000 9.885 4.753
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0100 0.071 0.071 0.028  0.3615.666 0.071 0.071  0.000  0.098  0.098  0.000 6.795 4.395
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0100 0.057 0.057              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0100 0.040 0.039              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0100 0.028 0.028              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.3402 0.033 0.437 0.0066 0.082 0.096 0.033  0.4322.584 0.070 0.096  0.027  0.120  0.119 -0.00110.284 3.592
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0066 0.071 0.080 0.028  0.3615.666 0.062 0.080  0.018  0.101  0.100  0.000 6.973 3.184
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0066 0.057 0.063 0.023  0.29 9.341 0.052 0.063  0.012  0.080  0.080  0.000 4.107 2.631
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0066 0.040 0.044 0.017  0.18 3.621 0.036 0.044  0.007  0.055  0.055  0.000 1.692 1.693
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0066 0.028 0.031 0.012  0.13 1.541 0.025 0.031  0.006  0.038  0.038  0.000 0.706 1.094
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN. SLOPE   HN    TERM.  SLOPE   HC     HN    ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.    COEFF (SIN)   M.    ENERGY (SIN)   M.     M.    DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                 M.                          M.    M.    N.     M.    M.     M.      M.     M.     M.    N.     M.

 8.0 0.15 0.015 0.3402 0.033 0.437 0.0050 0.082 0.107 0.033  0.4322.584 0.062 0.107  0.045  0.130  0.125 -0.00511.008 2.830
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0050 0.071 0.087 0.028  0.3615.666 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 2.659
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0050 0.057 0.069 0.023  0.29 9.341 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 2.236
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0050 0.040 0.047 0.017  0.18 3.621 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 1.436
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0050 0.028 0.033 0.012  0.13 1.541 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 0.936
 8.0 0.15 0.015 0.3402 0.033 0.437 0.0050 0.082 0.132 0.033  0.4322.584 0.049 0.132  0.083  0.181  0.144 -0.03713.660 1.596
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0050 0.071 0.101 0.028  0.3615.666 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 1.948
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0050 0.057 0.077 0.023  0.29 9.341 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 1.732
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0050 0.040 0.053 0.017  0.18 3.621 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 1.133
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0050 0.028 0.037 0.012  0.13 1.541 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.743
 8.0 0.15 0.015 0.3402 0.033 0.437 0.0025 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0025 0.071 0.112 0.028  0.3615.666 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 1.357
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0025 0.057 0.084 0.023  0.29 9.341 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 1.332
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0025 0.040 0.057 0.017  0.18 3.621 0.027 0.057  0.029  0.070  0.062 -0.008 2.070 0.886
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0025 0.028 0.039 0.012  0.13 1.541 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.593
 8.0 0.15 0.015 0.3402 0.033 0.437 0.0017 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.15 0.015 0.3402 0.028 0.370 0.0017 0.071 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 4.0 0.15 0.015 0.3402 0.023 0.292 0.0017 0.057 0.096 0.023  0.29 9.341 0.032 0.096  0.064  0.141  0.101 -0.040 6.199 0.826
 2.0 0.15 0.015 0.3402 0.017 0.195 0.0017 0.040 0.063 0.017  0.18 3.621 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.594
 1.0 0.15 0.015 0.3402 0.012 0.129 0.0017 0.028 0.044 0.012  0.13 1.541 0.017 0.044  0.027  0.059  0.046 -0.013 0.984 0.410
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                         TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE   HV  TERM.  SLOPE   HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)   M.  ENERGY (SIN)   M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                             M.                           M.    M.    N.    M.     M.    M.      M.    M.       M.   N.    M.

 8.0 0.15 0.015 0.5000 0.030 0.561 0.0250 0.082 0.064                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.5000 0.026 0.475 0.0250 0.071 0.055                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.5000 0.021 0.374 0.0250 0.057 0.044                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.5000 0.015 0.248 0.0250 0.040 0.031                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.5000 0.011 0.164 0.0250 0.028 0.022                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.5000 0.030 0.561 0.0125 0.082 0.079                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.5000 0.026 0.475 0.0125 0.071 0.067                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.5000 0.021 0.374 0.0125 0.057 0.053                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.5000 0.015 0.248 0.0125 0.040 0.037                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.5000 0.011 0.164 0.0125 0.028 0.026                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.5000 0.030 0.561 0.0100 0.082 0.084 0.030  0.5525.739 0.081 0.084  0.003  0.115  0.115  0.000 9.685 5.072
 6.0 0.15 0.015 0.5000 0.026 0.475 0.0100 0.071 0.071 0.026  0.4517.550 0.071 0.071  0.000  0.098  0.098  0.000 6.795 4.623
 4.0 0.15 0.015 0.5000 0.021 0.374 0.0100 0.057 0.057                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.5000 0.015 0.248 0.0100 0.040 0.039                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.5000 0.011 0.164 0.0100 0.028 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.5000 0.030 0.561 0.0066 0.082 0.096 0.030  0.5525.739 0.070 0.096  0.027  0.120  0.119 -0.00110.284 3.813
 6.0 0.15 0.015 0.5000 0.026 0.475 0.0066 0.071 0.080 0.026  0.4517.550 0.062 0.080  0.018  0.101  0.100  0.000 6.973 3.411
 4.0 0.15 0.015 0.5000 0.021 0.374 0.0066 0.057 0.063 0.022  0.3510.248 0.052 0.063  0.012  0.080  0.080  0.000 4.107 2.777
 2.0 0.15 0.015 0.5000 0.015 0.248 0.0066 0.040 0.044 0.016  0.22 4.111 0.036 0.044  0.007  0.055  0.055  0.000 1.692 1.826
 1.0 0.15 0.015 0.5000 0.011 0.164 0.0066 0.028 0.031 0.011  0.15 1.688 0.025 0.031  0.006  0.038  0.038  0.000 0.706 1.155
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```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                            TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA.  MANN. SLOPE    HN   TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.    COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                 M.                          M.    M.    N.    M.     M.    M.       M.    M.       M.    N.    M.

  8.0 0.15 0.015 0.5000 0.030 0.561 0.0050 0.082 0.107 0.030  0.5525.739 0.062 0.107  0.045  0.130  0.125 -0.00511.008 3.139
  6.0 0.15 0.015 0.5000 0.026 0.475 0.0050 0.071 0.087 0.026  0.4517.550 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 2.897
  4.0 0.15 0.015 0.5000 0.021 0.374 0.0050 0.057 0.069 0.022  0.3510.248 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 2.383
  2.0 0.15 0.015 0.5000 0.015 0.248 0.0050 0.040 0.047 0.016  0.22 4.111 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 1.571
  1.0 0.15 0.015 0.5000 0.011 0.164 0.0050 0.028 0.033 0.011  0.15 1.688 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 0.997
  8.0 0.15 0.015 0.5000 0.030 0.561 0.0050 0.082 0.132 0.030  0.5525.739 0.049 0.132  0.083  0.181  0.144 -0.03713.660 1.905
  6.0 0.15 0.015 0.5000 0.026 0.475 0.0050 0.071 0.101 0.026  0.4517.550 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.179
  4.0 0.15 0.015 0.5000 0.021 0.374 0.0050 0.057 0.077 0.022  0.3510.248 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 1.883
  2.0 0.15 0.015 0.5000 0.015 0.248 0.0050 0.040 0.053 0.016  0.22 4.111 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 1.259
  1.0 0.15 0.015 0.5000 0.011 0.164 0.0050 0.028 0.037 0.011  0.15 1.688 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.836
  8.0 0.15 0.015 0.5000 0.030 0.561 0.0025 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
  6.0 0.15 0.015 0.5000 0.026 0.475 0.0025 0.071 0.112 0.026  0.4517.550 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 1.585
  4.0 0.15 0.015 0.5000 0.021 0.374 0.0025 0.057 0.084 0.022  0.3510.248 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 1.478
  2.0 0.15 0.015 0.5000 0.015 0.248 0.0025 0.040 0.057 0.016  0.22 4.111 0.027 0.057  0.029  0.070  0.062 -0.006 2.070 1.018
  1.0 0.15 0.015 0.5000 0.011 0.164 0.0025 0.028 0.039 0.011  0.15 1.688 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.654
  8.0 0.15 0.015 0.5000 0.030 0.561 0.0017 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
  6.0 0.15 0.015 0.5000 0.026 0.475 0.0017 0.071 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.
  4.0 0.15 0.015 0.5000 0.021 0.374 0.0017 0.057 0.096 0.022  0.3510.248 0.032 0.096  0.064  0.141  0.101 -0.040 6.199 0.971
  2.0 0.15 0.015 0.5000 0.015 0.248 0.0017 0.040 0.063 0.016  0.22 4.111 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.725
  1.0 0.15 0.015 0.5000 0.011 0.164 0.0017 0.028 0.044 0.011  0.15 1.688 0.017 0.044  0.027  0.059  0.046 -0.013 0.984 0.473
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```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.



  COMMON DATA  APPROACH PIPE DATA                             TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA. MANN. SLOPE    HN  TEMP.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S   M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN  CHANGE F+M.  POS.
                               M.                           M.    M.    N.    M.     M.    M.     M.     M.     M.    N.    M.

 8.0 0.15 0.015 0.7070 0.027 0.705 0.0250 0.082 0.064                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0250 0.071 0.055                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0250 0.057 0.044                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0250 0.040 0.031                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0250 0.026 0.022                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.7070 0.027 0.705 0.0125 0.082 0.079                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0125 0.071 0.067                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0125 0.057 0.053                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0125 0.040 0.037                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0125 0.028 0.026                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.7070 0.027 0.705 0.0100 0.082 0.084 0.028  0.6728.695 0.081 0.084  0.003  0.115  0.115  0.000 9.685 5.303

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0100 0.071 0.071 0.024  0.5719.900 0.071 0.071  0.000  0.098  0.098  0.000 6.795 4.845

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0100 0.057 0.057                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0100 0.040 0.039                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0100 0.028 0.028                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.7070 0.027 0.705 0.0066 0.082 0.096 0.028  0.6728.695 0.070 0.096  0.027  0.120  0.119 -0.00110.284 4.042

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0066 0.071 0.080 0.024  0.5719.900 0.062 0.080  0.018  0.101  0.100 -0.001 6.973 3.637

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0066 0.057 0.063 0.019  0.4711.957 0.052 0.063  0.012  0.080  0.080  0.000 4.107 2.992

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0066 0.040 0.044 0.014  0.29 4.738 0.036 0.044  0.007  0.055  0.055  0.000 1.692 1.958

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0066 0.028 0.031 0.010  0.18 1.861 0.025 0.031  0.006  0.038  0.038  0.000 0.706 1.217
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```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN. SLOPE   HN    TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.    COEFF (SIN)   M.    ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                M.                           M.    M.     N.   M.     M.     M.      M.     M.      M.     N.     M.


 8.0 0.15 0.015 0.7070 0.027 0.705 0.0050 0.082 0.107 0.026  0.6728.695 0.062 0.107  0.045  0.130  0.125 -0.00511.608 3.359

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0050 0.071 0.087 0.024  0.5719.900 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 3.122

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0050 0.057 0.069 0.019  0.4711.957 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 2.593

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0050 0.040 0.047 0.014  0.29 4.738 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 1.736

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0050 0.028 0.033 0.010  0.18 1.861 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 1.058

 8.0 0.15 0.015 0.7070 0.027 0.705 0.0050 0.082 0.132 0.028  0.6728.695 0.049 0.132  0.083  0.181  0.144 -0.03713.660 2.132

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0050 0.071 0.101 0.024  0.5719.900 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.401

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0050 0.057 0.077 0.019  0.4711.957 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 2.095

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0050 0.040 0.053 0.014  0.29 4.738 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 1.399

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0050 0.028 0.037 0.010  0.18 1.861 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.856

 8.0 0.15 0.015 0.7070 0.027 0.705 0.0025 0.082 0.150             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0025 0.071 0.112 0.024  0.5719.900 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 1.804

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0025 0.057 0.084 0.019  0.4711.957 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 1.638

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0025 0.040 0.057 0.014  0.29 4.738 0.027 0.057  0.029  0.070  0.062 -0.006 2.670 1.153

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0025 0.028 0.039 0.010  0.18 1.861 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.716

 8.0 0.15 0.015 0.7070 0.027 0.705 0.0017 0.082 0.150             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0017 0.071 0.150             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.15 0.015 0.7070 0.019 0.469 0.0017 0.057 0.096 0.019  0.4711.957 0.032 0.096  0.064  0.141  0.101 -0.040 6.199 1.182

 2.0 0.15 0.015 0.7070 0.014 0.310 0.0017 0.040 0.063 0.014  0.29 4.738 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.861

 1.0 0.15 0.015 0.7070 0.010 0.205 0.0017 0.028 0.044 0.010  0.18 1.861 0.017 0.044  0.027  0.059  0.046 -0.013 0.964 0.532
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```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.



  COMMON DATA  APPROACH PIPE DATA                                      TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE   HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)   M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                              M.                          M.     M.    N.    M.     M.     M.      M.     M.     M.    N.    M.

 8.0 0.15 0.015 0.8660 0.026 0.808 0.0250 0.082 0.064              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.8660 0.023 0.683 0.0250 0.071 0.055              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.8660 0.019 0.536 0.0250 0.057 0.044              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.8660 0.013 0.355 0.0250 0.040 0.031              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.8660 0.010 0.234 0.0250 0.028 0.022              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.8660 0.026 0.808 0.0125 0.082 0.079              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.8660 0.023 0.683 0.0125 0.071 0.067              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.8660 0.019 0.536 0.0125 0.057 0.053              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.8660 0.013 0.355 0.0125 0.040 0.037              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.8660 0.010 0.234 0.0125 0.028 0.026              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.8660 0.026 0.808 0.0100 0.082 0.084 0.026  0.7831.030 0.081 0.084  0.003  0.115  0.115  0.000 9.685 5.455
 6.0 0.15 0.015 0.8660 0.023 0.683 0.0100 0.071 0.071 0.023  0.6320.815 0.071 0.071  0.000  0.098  0.098  0.000 6.795 4.919
 4.0 0.15 0.015 0.8660 0.019 0.536 0.0100 0.057 0.057              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.8660 0.013 0.355 0.0100 0.040 0.039              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.8660 0.010 0.234 0.0100 0.028 0.028              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.8660 0.026 0.808 0.0066 0.082 0.096 0.026  0.7831.030 0.070 0.096  0.027  0.120  0.119 -0.00110.284 4.193
 6.0 0.15 0.015 0.8660 0.023 0.683 0.0066 0.071 0.080 0.023  0.6320.815 0.062 0.080  0.018  0.101  0.100 -0.001 6.973 3.712
 4.0 0.15 0.015 0.8660 0.019 0.536 0.0066 0.057 0.063 0.019  0.5212.645 0.052 0.063  0.012  0.080  0.080  0.000 4.107 3.052
 2.0 0.15 0.015 0.8660 0.013 0.355 0.0066 0.040 0.044 0.013  0.34 5.120 0.036 0.044  0.007  0.055  0.055  0.000 1.692 2.023
 1.0 0.15 0.015 0.8660 0.010 0.234 0.0066 0.028 0.031 0.010  0.22 2.071 0.025 0.031  0.006  0.038  0.038  0.000 0.706 1.277
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PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY  ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F+N   DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+N.  POS.
                              M.                         M.    M.     N.    M.     M.    M.         M.    M.        M.    N.    M.


 8.0 0.15 0.015 0.8660 0.026 0.806 0.0050 0.082 0.107 0.026  0.7831.030 0.062 0.107  0.045  0.130  0.125 -0.00511.008 3.519

 6.0 0.15 0.015 0.8660 0.023 0.683 0.0050 0.071 0.087 0.023  0.6320.815 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 3.195

 4.0 0.15 0.015 0.8660 0.019 0.536 0.0050 0.057 0.069 0.019  0.5212.645 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 2.655

 2.0 0.15 0.015 0.8660 0.013 0.355 0.0050 0.040 0.047 0.013  0.34 5.120 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 1.772

 1.0 0.15 0.015 0.8660 0.010 0.234 0.0050 0.028 0.033 0.010  0.22 2.071 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 1.119

 8.0 0.15 0.015 0.8660 0.026 0.806 0.0050 0.082 0.132 0.026  0.7831.030 0.049 0.132  0.083  0.181  0.144 -0.03713.660 2.277

 6.0 0.15 0.015 0.8660 0.023 0.683 0.0050 0.071 0.101 0.023  0.6320.815 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.472

 4.0 0.15 0.015 0.8660 0.019 0.536 0.0050 0.057 0.077 0.019  0.5212.645 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 2.156

 2.0 0.15 0.015 0.8660 0.013 0.355 0.0050 0.040 0.053 0.013  0.34 5.120 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 1.455

 1.0 0.15 0.015 0.8660 0.010 0.234 0.0050 0.028 0.037 0.010  0.22 2.071 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.926

 8.0 0.15 0.015 0.8660 0.026 0.806 0.0025 0.082 0.150                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.8660 0.023 0.683 0.0025 0.071 0.112 0.023  0.6320.815 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 1.874

 4.0 0.15 0.015 0.8660 0.019 0.536 0.0025 0.057 0.084 0.019  0.5212.645 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 1.751

 2.0 0.15 0.015 0.8660 0.013 0.355 0.0025 0.040 0.057 0.013  0.34 5.120 0.027 0.057  0.029  0.070  0.062 -0.006 2.070 1.218

 1.0 0.15 0.015 0.8660 0.010 0.234 0.0025 0.028 0.039 0.010  0.22 2.071 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.775

 8.0 0.15 0.015 0.8660 0.026 0.806 0.0017 0.082 0.150                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.8660 0.023 0.683 0.0017 0.071 0.150                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.15 0.015 0.8660 0.019 0.536 0.0017 0.057 0.096 0.019  0.5212.645 0.032 0.096  0.064  0.141  0.101 -0.040 6.199 1.252

 2.0 0.15 0.015 0.8660 0.013 0.355 0.0017 0.040 0.063 0.013  0.34 5.120 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.924

 1.0 0.15 0.015 0.8660 0.010 0.234 0.0017 0.028 0.044 0.010  0.22 2.071 0.017 0.044  0.027  0.059  0.046 -0.013 0.984 0.591
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                               TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN    TERM.  SLOPE    HC     HN   ENTRY  ENTRY  ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.    COEFF  (SIN)    M.    ENERGY (SIN)    M.     M.   DEPTH  ENERGY F+M   DEPTH  DEPTH  CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                  M.                           M.     M.     N.    M.     M.     M.     M.     M.     M.     N.    M.

8.0 0.15 0.015 0.9659 0.025 0.871 0.0250 0.082 0.064                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.15 0.015 0.9659 0.022 0.735 0.0250 0.071 0.055                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.9659 0.018 0.578 0.0250 0.057 0.044                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.9659 0.013 0.381 0.0250 0.040 0.031                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.9659 0.009 0.251 0.0250 0.028 0.022                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.9659 0.025 0.871 0.0125 0.082 0.079                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.15 0.015 0.9659 0.022 0.735 0.0125 0.071 0.067                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.9659 0.018 0.578 0.0125 0.057 0.053                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.9659 0.013 0.381 0.0125 0.040 0.037                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.9659 0.009 0.251 0.0125 0.028 0.026                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.9659 0.025 0.871 0.0100 0.082 0.084 0.025  0.8532.330 0.061 0.084  0.003  0.115  0.115  0.000 9.885 5.531

6.0 0.15 0.015 0.9659 0.022 0.735 0.0100 0.071 0.071 0.022  0.6921.807 0.071 0.071  0.000  0.098  0.098  0.000 6.795 4.992

4.0 0.15 0.015 0.9659 0.018 0.578 0.0100 0.057 0.057                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.9659 0.013 0.381 0.0100 0.040 0.039                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.9659 0.009 0.251 0.0100 0.028 0.028                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.9659 0.025 0.871 0.0066 0.082 0.096 0.025  0.8532.330 0.070 0.096  0.027  0.120  0.119 -0.00110.284 4.258

6.0 0.15 0.015 0.9659 0.022 0.735 0.0066 0.071 0.080 0.022  0.6921.807 0.062 0.080  0.018  0.101  0.100 -0.001 6.973 3.785

4.0 0.15 0.015 0.9659 0.018 0.578 0.0066 0.057 0.063 0.019  0.5212.645 0.052 0.063  0.012  0.080  0.080  0.000 4.107 3.052

2.0 0.15 0.015 0.9659 0.013 0.381 0.0066 0.040 0.044 0.013  0.34 5.120 0.036 0.044  0.007  0.055  0.055  0.000 1.692 2.023

1.0 0.15 0.015 0.9659 0.009 0.251 0.0066 0.028 0.031 0.010  0.22 2.071 0.025 0.031  0.006  0.038  0.038  0.000 0.706 1.277
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


 COMMON DATA  APPROACH PIPE DATA                           TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN  TEMP.  SLOPE    HC    HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.    M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                             M.                          M.    M.    N.    M.     M.     M.     M.     M.      M.    N.    M.


 8.0 0.15 0.015 0.9659 0.025 0.871 0.0050 0.082 0.107 0.025  0.8532.330 0.062 0.107  0.045  0.130  0.125 -0.00511.008 3.594

 6.0 0.15 0.015 0.9659 0.022 0.735 0.0050 0.071 0.087 0.022  0.6921.807 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 3.259

 4.0 0.15 0.015 0.9659 0.018 0.578 0.0050 0.057 0.069 0.019  0.5212.645 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 2.655

 2.0 0.15 0.015 0.9659 0.013 0.381 0.0050 0.040 0.047 0.013  0.34 5.120 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 1.772

 1.0 0.15 0.015 0.9659 0.009 0.251 0.0050 0.028 0.033 0.010  0.22 2.071 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 1.119

 8.0 0.15 0.015 0.9659 0.025 0.871 0.0050 0.082 0.132 0.025  0.8532.330 0.049 0.132  0.083  0.181  0.144 -0.03713.660 2.355

 6.0 0.15 0.015 0.9659 0.022 0.735 0.0050 0.071 0.101 0.022  0.6921.807 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.543

 4.0 0.15 0.015 0.9659 0.018 0.578 0.0050 0.057 0.077 0.019  0.5212.645 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 2.156

 2.0 0.15 0.015 0.9659 0.013 0.381 0.0050 0.040 0.053 0.013  0.34 5.120 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 1.465

 1.0 0.15 0.015 0.9659 0.009 0.251 0.0050 0.028 0.037 0.010  0.22 2.071 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.926

 8.0 0.15 0.015 0.9659 0.025 0.871 0.0025 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.9659 0.022 0.735 0.0025 0.071 0.112 0.022  0.6921.807 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 1.951

 4.0 0.15 0.015 0.9659 0.018 0.578 0.0025 0.057 0.084 0.019  0.5212.645 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 1.751

 2.0 0.15 0.015 0.9659 0.013 0.381 0.0025 0.040 0.057 0.013  0.34 5.120 0.027 0.057  0.029  0.070  0.062 -0.008 2.070 1.218

 1.0 0.15 0.015 0.9659 0.009 0.251 0.0025 0.028 0.039 0.010  0.22 2.071 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.775

 8.0 0.15 0.015 0.9659 0.025 0.871 0.0017 0.082 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.15 0.015 0.9659 0.022 0.735 0.0017 0.071 0.150              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.15 0.015 0.9659 0.018 0.578 0.0017 0.057 0.096 0.019  0.5212.645 0.032 0.096  0.064  0.141  0.101 -0.040 6.199 1.252

 2.0 0.15 0.015 0.9659 0.013 0.381 0.0017 0.040 0.063 0.013  0.34 5.120 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.924

 1.0 0.15 0.015 0.9659 0.009 0.251 0.0017 0.028 0.044 0.010  0.22 2.071 0.017 0.044  0.027  0.059  0.046 -0.013 0.984 0.591
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                                 TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA.  MANN.  SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S   M.    COEFF  (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                   M.                           M.    M.    N.    M.     M.    M.       M.    M.       M.    N.     M.


 8.0 0.15 0.015 1.0000 0.025 0.892 0.0050 0.082 0.107 0.025  0.6532.330 0.062 0.107  0.045  0.130  0.125 -0.00511.008 3.594
 6.0 0.15 0.015 1.0000 0.022 0.752 0.0050 0.071 0.087 0.022  0.6921.807 0.057 0.087  0.031  0.106  0.103 -0.002 7.313 3.259
 4.0 0.15 0.015 1.0000 0.018 0.591 0.0050 0.057 0.069 0.018  0.5813.406 0.047 0.069  0.021  0.083  0.082 -0.001 4.265 2.735
 2.0 0.15 0.015 1.0000 0.013 0.390 0.0050 0.040 0.047 0.013  0.34 5.120 0.034 0.047  0.013  0.057  0.056 -0.001 1.750 1.772
 1.0 0.15 0.015 1.0000 0.009 0.257 0.0050 0.028 0.033 0.010  0.22 2.071 0.024 0.033  0.010  0.040  0.039 -0.001 0.730 1.119
 8.0 0.15 0.015 1.0000 0.025 0.892 0.0050 0.082 0.132 0.025  0.8532.330 0.049 0.132  0.083  0.181  0.144 -0.03713.660 2.356
 6.0 0.15 0.015 1.0000 0.022 0.752 0.0050 0.071 0.101 0.022  0.6921.807 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.543
 4.0 0.15 0.015 1.0000 0.018 0.591 0.0050 0.057 0.077 0.018  0.5813.406 0.041 0.077  0.036  0.094  0.087 -0.007 4.712 2.234
 2.0 0.15 0.015 1.0000 0.013 0.390 0.0050 0.040 0.053 0.013  0.34 5.120 0.030 0.053  0.023  0.063  0.059 -0.004 1.906 1.466
 1.0 0.15 0.015 1.0000 0.009 0.257 0.0050 0.028 0.037 0.010  0.22 2.071 0.021 0.037  0.016  0.044  0.041 -0.003 0.795 0.926
 8.0 0.15 0.015 1.0000 0.025 0.892 0.0025 0.082 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.15 0.015 1.0000 0.022 0.752 0.0025 0.071 0.112 0.022  0.6921.807 0.042 0.112  0.070  0.152  0.121 -0.031 9.511 1.951
 4.0 0.15 0.015 1.0000 0.018 0.591 0.0025 0.057 0.084 0.018  0.5813.406 0.037 0.084  0.047  0.107  0.092 -0.015 5.193 1.833
 2.0 0.15 0.015 1.0000 0.013 0.390 0.0025 0.040 0.057 0.013  0.34 5.120 0.027 0.057  0.029  0.070  0.062 -0.006 2.070 1.218
 1.0 0.15 0.015 1.0000 0.009 0.257 0.0025 0.028 0.039 0.010  0.22 2.071 0.019 0.039  0.020  0.049  0.043 -0.005 0.659 0.775
 8.0 0.15 0.015 1.0000 0.025 0.892 0.0017 0.082 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 6.0 0.15 0.015 1.0000 0.022 0.752 0.0017 0.071 0.150                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 4.0 0.15 0.015 1.0000 0.018 0.591 0.0017 0.057 0.096 0.018  0.5813.406 0.032 0.096  0.064  0.141  0.101 -0.040 6.199 1.325
 2.0 0.15 0.015 1.0000 0.013 0.390 0.0017 0.040 0.063 0.013  0.34 5.120 0.024 0.063  0.039  0.086  0.067 -0.019 2.386 0.924
 1.0 0.15 0.015 1.0000 0.009 0.257 0.0017 0.028 0.044 0.010  0.22 2.071 0.017 0.044  0.027  0.059  0.046 -0.013 0.984 0.591
```

```
PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM OF THE JUMP IN THE TEST PIPE.


  COMMON DATA  APPROACH PIPE DATA                           TEST PIPE DATA AND PROGRAM RESULTS.

  Q.   DIA. MANN. SLOPE    HN  TERR.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S   M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                M.                         M.    M.    N.    M.     M.    M.      M.    M.      M.    N.     M.

  8.0 0.15 0.015 1.0000 0.025 0.892 0.0250 0.082 0.064                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  6.0 0.15 0.015 1.0000 0.022 0.752 0.0250 0.071 0.055                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  4.0 0.15 0.015 1.0000 0.018 0.591 0.0250 0.057 0.044                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  2.0 0.15 0.015 1.0000 0.013 0.390 0.0250 0.040 0.031                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  1.0 0.15 0.015 1.0000 0.009 0.257 0.0250 0.028 0.022                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  8.0 0.15 0.015 1.0000 0.025 0.892 0.0125 0.082 0.079                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  6.0 0.15 0.015 1.0000 0.022 0.752 0.0125 0.071 0.067                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  4.0 0.15 0.015 1.0000 0.018 0.591 0.0125 0.057 0.053                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  2.0 0.15 0.015 1.0000 0.013 0.390 0.0125 0.040 0.037                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  1.0 0.15 0.015 1.0000 0.009 0.257 0.0125 0.028 0.026                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  8.0 0.15 0.015 1.0000 0.025 0.892 0.0100 0.082 0.084 0.025  0.6532.330 0.081 0.084  0.003  0.115  0.115  0.000 9.685 5.531

  6.0 0.15 0.015 1.0000 0.022 0.752 0.0100 0.071 0.071 0.022  0.6921.807 0.071 0.071  0.000  0.098  0.098  0.000 6.795 4.992

  4.0 0.15 0.015 1.0000 0.018 0.591 0.0100 0.057 0.057                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  2.0 0.15 0.015 1.0000 0.013 0.390 0.0100 0.040 0.039                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  1.0 0.15 0.015 1.0000 0.009 0.257 0.0100 0.028 0.028                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

  8.0 0.15 0.015 1.0000 0.025 0.892 0.0066 0.082 0.096 0.025  0.6532.330 0.070 0.096  0.027  0.120  0.119 -0.00110.284 4.268

  6.0 0.15 0.015 1.0000 0.022 0.752 0.0066 0.071 0.080 0.022  0.6921.807 0.062 0.080  0.018  0.101  0.100 -0.001 6.973 3.785

  4.0 0.15 0.015 1.0000 0.018 0.591 0.0066 0.057 0.063 0.018  0.5813.406 0.052 0.063  0.012  0.080  0.080  0.000 4.107 3.132

  2.0 0.15 0.015 1.0000 0.013 0.390 0.0066 0.040 0.044 0.013  0.34 5.120 0.036 0.044  0.007  0.055  0.055  0.000 1.692 2.023

  1.0 0.15 0.015 1.0000 0.009 0.257 0.0066 0.028 0.031 0.010  0.22 2.071 0.025 0.031  0.006  0.038  0.038  0.000 0.706 1.277
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APPENDIX 4

JUMP LOCATION IN A 0.075 m WIDE RECTANGULAR CHANNEL, MANNING COEFFICIENT 0.015, AT SLOPES 1/40, 1/80, 1/100, 1/200

```
 COMMON DATA  APPROACH PIPE DATA                                       TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN  CHANGE F+M.  POS.
                              M.                          M.    M.     N.    M.     M.    M.      M.    M.     M.    N.    M.

 8.0 0.07 0.015 0.0349 0.075 0.178 0.0250 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.0349 0.075 0.133 0.0250 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.0349 0.054 0.104 0.0250 0.066 0.062                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.07 0.015 0.0349 0.032 0.067 0.0250 0.042 0.036                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.0349 0.020 0.043 0.0250 0.026 0.022                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.0349 0.075 0.178 0.0125 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.0349 0.075 0.133 0.0125 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.0349 0.054 0.104 0.0125 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0349 0.032 0.067 0.0125 0.042 0.047 0.023  0.09 2.497 0.037 0.047  0.010  0.064  0.063 -0.003 1.949 0.753

 1.0 0.07 0.015 0.0349 0.020 0.043 0.0125 0.026 0.028 0.014  0.06 0.999 0.025 0.028  0.004  0.040  0.040 -0.000 0.765 0.522

 8.0 0.07 0.015 0.0349 0.075 0.178 0.0100 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.


 6.0 0.07 0.015 0.0349 0.075 0.133 0.0100 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.0349 0.054 0.104 0.0100 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0349 0.032 0.067 0.0100 0.042 0.051 0.023  0.09 2.497 0.033 0.051  0.018  0.066  0.065 -0.001 2.609 0.555

 1.0 0.07 0.015 0.0349 0.020 0.043 0.0100 0.026 0.030 0.014  0.06 0.999 0.023 0.030  0.008  0.040  0.040 -0.000 0.779 0.476

 8.0 0.07 0.015 0.0349 0.075 0.178 0.0050 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.0349 0.075 0.133 0.0050 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.0349 0.054 0.104 0.0050 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0349 0.032 0.067 0.0050 0.042 0.068 0.023  0.09 2.497 0.023 0.068  0.044  0.089  0.076 -0.014 2.474 0.313

 1.0 0.07 0.015 0.0349 0.020 0.043 0.0050 0.026 0.039 0.014  0.06 0.999 0.016 0.039  0.023  0.050  0.045 -0.005 0.909 0.124
* PROGRAM RESULTS BASED ON TERMINAL CONDITIONS IN THE APPROACH PIPE AND NORMAL
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 COMMON DATA  APPROACH PIPE DATA                                 TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)   M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                          M.    M.    N.    M.     M.    M.     M.     M.     M.     N.    %.

 8.0 0.07 0.015 0.0698 0.072 0.185 0.0250 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.0698 0.057 0.158 0.0250 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.0698 0.041 0.126 0.0250 0.066 0.062             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.025 0.083 0.0250 0.042 0.036             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.0698 0.015 0.054 0.0250 0.026 0.022             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.0698 0.072 0.185 0.0125 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.0698 0.057 0.158 0.0125 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.0698 0.041 0.126 0.0125 0.066 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.025 0.083 0.0125 0.042 0.047 0.021  0.10 2.717 0.037 0.047  0.010  0.064  0.063 -0.001 1.949 0.918

 1.0 0.07 0.015 0.0698 0.015 0.054 0.0125 0.026 0.028 0.013  0.07 1.089 0.025 0.029  0.004  0.040  0.040 -0.000 0.765 0.725

 8.0 0.07 0.015 0.0698 0.072 0.185 0.0100 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.0698 0.057 0.158 0.0100 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.0698 0.041 0.126 0.0100 0.066 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.025 0.083 0.0100 0.042 0.051 0.021  0.10 2.717 0.033 0.051  0.018  0.066  0.065 -0.001 2.009 0.718

 1.0 0.07 0.015 0.0698 0.015 0.054 0.0100 0.026 0.030 0.013  0.07 1.089 0.023 0.030  0.007  0.040  0.040 -0.000 0.779 0.577

 8.0 0.07 0.015 0.0698 0.072 0.185 0.0050 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.0698 0.057 0.158 0.0050 0.075 0.075             JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.


 4.0 0.07 0.015 0.0698 0.041 0.126 0.0050 0.066 0.075             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.0698 0.025 0.083 0.0050 0.042 0.068 0.021  0.10 2.717 0.023 0.068  0.044  0.089  0.076 -0.014 2.474 0.151

 1.0 0.07 0.015 0.0698 0.015 0.054 0.0050 0.026 0.039 0.013  0.07 1.089 0.016 0.039  0.023  0.050  0.045 -0.005 0.909 0.219
 COMMON DATA  APPROACH PIPE DATA                                 TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY  ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COFF  (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M   DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                                M.                          M.    M.     N.    M.     M.    M.        M.     M.     M.    N.    M.

 8.0 0.07 0.015 0.1045 0.061 0.218 0.0250 0.076 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.1045 0.049 0.187 0.0250 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.1045 0.036 0.150 0.0250 0.066 0.062                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.022 0.099 0.0250 0.042 0.036                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.1045 0.013 0.064 0.0250 0.026 0.022                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.1045 0.061 0.218 0.0125 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.1045 0.049 0.187 0.0125 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.1045 0.036 0.150 0.0125 0.066 0.075               FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.022 0.099 0.0125 0.042 0.047 0.019  0.12 2.927 0.037 0.047  0.010  0.064  0.063 -0.003 1.949 1.330

 1.0 0.07 0.015 0.1045 0.013 0.064 0.0125 0.026 0.028 0.012  0.08 1.170 0.025 0.028  0.003  0.040  0.040 -0.003 0.755 0.831

 8.0 0.07 0.015 0.1045 0.061 0.218 0.0100 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.1045 0.049 0.187 0.0100 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.1045 0.036 0.150 0.0100 0.066 0.075               FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.022 0.099 0.0100 0.042 0.051 0.019  0.12 2.927 0.033 0.051  0.018  0.066  0.065 -0.001 2.009 0.836

 1.0 0.07 0.015 0.1045 0.013 0.064 0.0100 0.026 0.030 0.012  0.08 1.170 0.022 0.030  0.008  0.040  0.040 -0.003 0.779 0.553

 8.0 0.07 0.015 0.1045 0.061 0.218 0.0050 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.1045 0.049 0.187 0.0050 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.1045 0.036 0.150 0.0050 0.066 0.075               FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.1045 0.022 0.099 0.0050 0.042 0.068 0.019  0.12 2.927 0.023 0.058  0.044  0.089  0.076 -0.014 2.474 0.275

 1.0 0.07 0.015 0.1045 0.013 0.064 0.0050 0.026 0.039 0.012  0.08 1.170 0.016 0.039  0.023  0.050  0.045 -0.005 0.904 0.273
[illegible]
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COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE   HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COFF  (SIN)   M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN  CHANGE F.NO  POS.
                             M.                           M.    M.    NO.   M.     M.     M.     M.     M.     M.    NO.   M.

 8.0 0.07 0.015 0.1736 0.050 0.284 0.0250 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 6.0 0.07 0.015 0.1736 0.040 0.244 0.0250 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 4.0 0.07 0.015 0.1736 0.030 0.195 0.0250 0.066 0.062                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.07 0.015 0.1736 0.018 0.129 0.0250 0.042 0.036                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.07 0.015 0.1736 0.011 0.082 0.0250 0.026 0.022                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.07 0.015 0.1736 0.050 0.284 0.0125 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 6.0 0.07 0.015 0.1736 0.040 0.244 0.0125 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 4.0 0.07 0.015 0.1736 0.030 0.195 0.0125 0.066 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 2.0 0.07 0.015 0.1736 0.018 0.129 0.0125 0.042 0.047 0.017  0.15 3.282 0.037 0.047  0.010  0.064  0.063 -0.000 1.449 1.139
 1.0 0.07 0.015 0.1736 0.011 0.082 0.0125 0.026 0.028 0.011  0.09 1.307 0.025 0.028  0.003  0.040  0.040 -0.000 0.765 0.931
 8.0 0.07 0.015 0.1736 0.050 0.284 0.0100 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 6.0 0.07 0.015 0.1736 0.040 0.244 0.0100 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 4.0 0.07 0.015 0.1736 0.030 0.195 0.0100 0.066 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 2.0 0.07 0.015 0.1736 0.018 0.129 0.0100 0.042 0.051 0.017  0.15 3.282 0.033 0.051  0.018  0.066  0.065 -0.001 2.009 0.995
 1.0 0.07 0.015 0.1736 0.011 0.082 0.0100 0.026 0.030 0.011  0.09 1.307 0.023 0.030  0.008  0.040  0.040 -0.000 0.779 0.769
 8.0 0.07 0.015 0.1736 0.050 0.284 0.0050 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 6.0 0.07 0.015 0.1736 0.040 0.244 0.0050 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
 4.0 0.07 0.015 0.1736 0.030 0.195 0.0050 0.066 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.
 2.0 0.07 0.015 0.1736 0.018 0.129 0.0050 0.042 0.068 0.017  0.15 3.282 0.023 0.063  0.044  0.089  0.076 -0.014 2.474 0.923
 1.0 0.07 0.015 0.1736 0.011 0.082 0.0050 0.026 0.039 0.011  0.09 1.307 0.017 0.037  0.023  0.050  0.045 -0.005 0.909 0.986
 COMMON DATA  APPROACH PIPE DATA                                   TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  PDS.
                               M.                         M.    M.    N.    M.     M.    M.       M.    M.     M.    N.    %.

 8.0 0.07 0.015 0.3402 0.038 0.430 0.0250 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.3402 0.031 0.368 0.0250 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.



 4.0 0.07 0.015 0.3402 0.023 0.292 0.0250 0.066 0.062                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.07 0.015 0.3402 0.014 0.190 0.0250 0.042 0.036                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.3402 0.009 0.119 0.0250 0.026 0.022                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.3402 0.038 0.430 0.0125 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.3402 0.031 0.368 0.0125 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.3402 0.023 0.292 0.0125 0.066 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.3402 0.014 0.190 0.0125 0.042 0.047 0.014  0.20 3.928 0.037 0.047  0.010  0.064  0.063 -0.001 1.949 1.411

 1.0 0.07 0.015 0.3402 0.009 0.119 0.0125 0.026 0.028 0.009  0.13 1.555 0.025 0.028  0.003  0.040  0.040 -0.001 0.765 1.327

 8.0 0.07 0.015 0.3402 0.038 0.430 0.0100 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.3402 0.031 0.368 0.0100 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.3402 0.023 0.292 0.0100 0.066 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.3402 0.014 0.190 0.0100 0.042 0.051 0.014  0.20 3.928 0.033 0.051  0.018  0.066  0.065 -0.001 2.009 1.236

 1.0 0.07 0.015 0.3402 0.009 0.119 0.0100 0.026 0.030 0.009  0.13 1.555 0.023 0.030  0.008  0.040  0.040 -0.005 0.779 0.975

 8.0 0.07 0.015 0.3402 0.038 0.430 0.0050 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.3402 0.031 0.368 0.0050 0.075 0.075                JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.3402 0.023 0.292 0.0050 0.066 0.075                FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.3402 0.014 0.190 0.0050 0.042 0.068 0.014  0.20 3.928 0.024 0.068  0.044  0.089  0.076 -0.014 2.474 0.534

 1.0 0.07 0.015 0.3402 0.009 0.119 0.0050 0.026 0.039 0.009  0.13 1.555 0.017 0.039  0.023  0.050  0.045 -0.005 0.909 0.513
 COMMON DATA  APPROACH PIPE DATA                                     TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC       HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH   ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.  ENERGY (SIN)    M.       M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE  UPJUMP DOWN   CHANGE F.N.  POS.
                                M.                            M.    M.    N.    M.     M.    M.        M.    M.     M.    N.    M.

 8.0 0.07 0.015 0.5000 0.033 0.555 0.0250 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.5000 0.027 0.473 0.0250 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.5000 0.020 0.373 0.0250 0.066 0.062                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.07 0.015 0.5000 0.013 0.239 0.0250 0.042 0.036                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.5000 0.006 0.149 0.0250 0.026 0.022                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.5000 0.033 0.555 0.0125 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.5000 0.027 0.473 0.0125 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.



 4.0 0.07 0.015 0.5000 0.020 0.373 0.0125 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.5000 0.013 0.239 0.0125 0.042 0.047 0.012  0.25 4.390 0.037 0.047  0.010  0.064  0.063 -0.000 1.949 1.523

 1.0 0.07 0.015 0.5000 0.008 0.149 0.0125 0.026 0.029 0.003  0.16 1.731 0.025 0.029  0.003  0.040  0.043 -0.003 0.765 1.336

 8.0 0.07 0.015 0.5000 0.033 0.555 0.0100 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.5000 0.027 0.473 0.0100 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.5000 0.020 0.373 0.0100 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.5000 0.013 0.239 0.0100 0.042 0.051 0.012  0.25 4.390 0.033 0.051  0.018  0.066  0.065 -0.001 2.009 1.312

 1.0 0.07 0.015 0.5000 0.008 0.149 0.0100 0.026 0.030 0.003  0.16 1.731 0.023 0.030  0.008  0.040  0.040 -0.000 0.779 0.933

 8.0 0.07 0.015 0.5000 0.033 0.555 0.0050 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.5000 0.027 0.473 0.0050 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.5000 0.020 0.373 0.0050 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.5000 0.013 0.239 0.0050 0.042 0.068 0.012  0.25 4.390 0.024 0.068  0.044  0.089  0.076 -0.014 2.474 0.742

 1.0 0.07 0.015 0.5000 0.008 0.149 0.0050 0.026 0.039 0.003  0.16 1.731 0.016 0.039  0.023  0.050  0.045 -0.005 0.909 0.573
 COMMON DATA  APPROACH PIPE DATA                         TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN. SLOPE   HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.    COFF  (SIN)   M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                M.                          M.    M.    N.    M.     M.    M.      M.     M.     M.     N.    M.

8.0 0.07 0.015 0.7070 0.029 0.701 0.0250 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

6.0 0.07 0.015 0.7070 0.024 0.595 0.0250 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

4.0 0.07 0.015 0.7070 0.018 0.466 0.0250 0.066 0.062                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.07 0.015 0.7070 0.011 0.297 0.0250 0.042 0.036                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.07 0.015 0.7070 0.007 0.183 0.0250 0.026 0.022                   JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.07 0.015 0.7070 0.029 0.701 0.0125 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

6.0 0.07 0.015 0.7070 0.024 0.595 0.0125 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

4.0 0.07 0.015 0.7070 0.018 0.466 0.0125 0.066 0.075                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.7070 0.011 0.297 0.0125 0.042 0.047 0.011  0.31 4.870 0.037 0.047  0.010  0.064  0.063 -0.003 1.949 1.580

1.0 0.07 0.015 0.7070 0.007 0.183 0.0125 0.026 0.028 0.007  0.19 1.912 0.025 0.028  0.003  0.040  0.040 -0.003 0.765 1.147

8.0 0.07 0.015 0.7070 0.029 0.701 0.0100 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

6.0 0.07 0.015 0.7070 0.024 0.595 0.0100 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

4.0 0.07 0.015 0.7070 0.018 0.466 0.0100 0.066 0.075                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.



2.0 0.07 0.015 0.7070 0.011 0.297 0.0100 0.042 0.051 0.011  0.31 4.870 0.033 0.051  0.018  0.066  0.065 -0.001 2.009 1.433

1.0 0.07 0.015 0.7070 0.007 0.183 0.0100 0.026 0.030 0.007  0.19 1.912 0.022 0.030  0.008  0.040  0.043 -0.003 0.779 0.332

8.0 0.07 0.015 0.7070 0.029 0.701 0.0050 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

6.0 0.07 0.015 0.7070 0.024 0.595 0.0050 0.075 0.075                   JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

4.0 0.07 0.015 0.7070 0.018 0.466 0.0050 0.066 0.075                   FULL BORE FLOW ESTABLISHED IN TEST PIPE.

2.0 0.07 0.015 0.7070 0.011 0.297 0.0050 0.042 0.068 0.011  0.31 4.870 0.023 0.068  0.044  0.089  0.076 -0.014 2.474 0.820

1.0 0.07 0.015 0.7070 0.007 0.183 0.0050 0.026 0.039 0.007  0.19 1.912 0.017 0.039  0.023  0.050  0.045 -0.005 0.409 0.526
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 COMMON DATA  APPROACH PIPE DATA                                    TEST PIPE DATA AND PROGRAM RESULTS.

  J.   DIA. MANN. SLOPE    HN  TERM.  SLOPE    MC      HN   ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH   ENERGY ENERGY ENERGY JUMP  JUMP
 L/S   M.   COEFF (SIN)    M.  ENERGY (SIN)    M.      M.   DEPTH ENERGY F.M  DEPTH  DEPTH CHANGE  UPJUMP DOWN   CHANGE F.M.  POS.
                                 M.                           M.    M.    N.    M.     M.     M.      M.     M.     M.     N.    M.

 8.0 0.07 0.015 0.8660 0.027 0.805 0.0250 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.8660 0.022 0.681 0.0250 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.8660 0.017 0.532 0.0250 0.066 0.062                  JUMP IMPOSSIBLE AS HN<MC IN TEST PIPE.

 2.0 0.07 0.015 0.8660 0.011 0.337 0.0250 0.042 0.036                  JUMP IMPOSSIBLE AS HN<MC IN TEST PIPE.

 1.0 0.07 0.015 0.8660 0.007 0.207 0.0250 0.026 0.022                  JUMP IMPOSSIBLE AS HN<MC IN TEST PIPE.

 8.0 0.07 0.015 0.8660 0.027 0.805 0.0125 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.8660 0.022 0.681 0.0125 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.8660 0.017 0.532 0.0125 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.8660 0.011 0.337 0.0125 0.042 0.047 0.013  0.35 5.182 0.037 0.047  0.010  0.064  0.063 -0.003 1.949 1.653

 1.0 0.07 0.015 0.8660 0.007 0.207 0.0125 0.026 0.028 0.007  0.21 2.032 0.025 0.028  0.003  0.040  0.040 -0.000 0.765 1.176

 8.0 0.07 0.015 0.8660 0.027 0.805 0.0100 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.8660 0.022 0.681 0.0100 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.8660 0.017 0.532 0.0100 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.8660 0.011 0.337 0.0100 0.042 0.051 0.013  0.35 5.182 0.033 0.051  0.018  0.066  0.065 -0.001 2.609 1.443

 1.0 0.07 0.015 0.8660 0.007 0.207 0.0100 0.026 0.030 0.007  0.21 2.032 0.023 0.030  0.008  0.040  0.040 -0.003 0.779 1.321

 8.0 0.07 0.015 0.8660 0.027 0.805 0.0050 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.8660 0.022 0.681 0.0050 0.075 0.075                  JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.8660 0.017 0.532 0.0050 0.066 0.075                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.



 2.0 0.07 0.015 0.8660 0.011 0.337 0.0050 0.042 0.068 0.010  0.35 5.182 0.024 0.053  0.044  0.089  0.076 -0.014 2.474 3.879

 1.0 0.07 0.015 0.8660 0.007 0.207 0.0050 0.026 0.039 0.007  0.21 2.032 0.017 0.034  0.023  0.050  0.045 -0.005 0.909 0.555
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN   TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)   M.   ENERGY (SIN)    M.     M.  DEPTH ENERGY F.N  DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                               M.                          M.    M.    N.    M.    M.    M.      M.    M.     M.     N.   M.

 8.0 0.07 0.015 0.9659 0.026 0.869 0.0250 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.9659 0.021 0.733 0.0250 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.9659 0.016 0.571 0.0250 0.066 0.062                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.07 0.015 0.9659 0.010 0.360 0.0250 0.042 0.036                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.07 0.015 0.9659 0.006 0.221 0.0250 0.026 0.022                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.07 0.015 0.9659 0.026 0.869 0.0125 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.9659 0.021 0.733 0.0125 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.9659 0.016 0.571 0.0125 0.066 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.9659 0.010 0.360 0.0125 0.042 0.047 0.010  0.37 5.356 0.037 0.047  0.010  0.064  0.063 -0.003 1.949 1.593

 1.0 0.07 0.015 0.9659 0.006 0.221 0.0125 0.026 0.028 0.006  0.23 2.099 0.025 0.028  0.003  0.040  0.040 -0.003 0.755 1.171

 8.0 0.07 0.015 0.9659 0.026 0.869 0.0100 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.9659 0.021 0.733 0.0100 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.9659 0.016 0.571 0.0100 0.066 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.9659 0.010 0.360 0.0100 0.042 0.051 0.010  0.37 5.356 0.033 0.051  0.018  0.066  0.065 -0.001 2.009 1.473

 1.0 0.07 0.015 0.9659 0.006 0.221 0.0100 0.026 0.030 0.006  0.23 2.099 0.023 0.033  0.008  0.040  0.040 -0.003 0.779 1.335

 8.0 0.07 0.015 0.9659 0.026 0.869 0.0050 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.07 0.015 0.9659 0.021 0.733 0.0050 0.075 0.075                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 4.0 0.07 0.015 0.9659 0.016 0.571 0.0050 0.066 0.075                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 2.0 0.07 0.015 0.9659 0.010 0.360 0.0050 0.042 0.068 0.010  0.37 5.356 0.024 0.068  0.044  0.089  0.076 -0.014 2.474 0.706

 1.0 0.07 0.015 0.9659 0.006 0.221 0.0050 0.026 0.039 0.006  0.23 2.099 0.017 0.039  0.023  0.050  0.045 -0.005 0.934 0.573
 COMMON DATA  APPROACH PIPE DATA                    TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA.  MANN. SLOPE   HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.    COEFF (SIN)   M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                               M.                          M.    M.    N.    M.     M.    M.      M.     M.     M.    N.    M.

8.0 0.07 0.015 1.0000 0.026 0.890 0.0250 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
6.0 0.07 0.015 1.0000 0.021 0.750 0.0250 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
4.0 0.07 0.015 1.0000 0.016 0.584 0.0250 0.066 0.062               JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
2.0 0.07 0.015 1.0000 0.010 0.368 0.0250 0.042 0.036               JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
1.0 0.07 0.015 1.0000 0.006 0.226 0.0250 0.026 0.022               JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
8.0 0.07 0.015 1.0000 0.026 0.890 0.0125 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
6.0 0.07 0.015 1.0000 0.021 0.750 0.0125 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
4.0 0.07 0.015 1.0000 0.016 0.584 0.0125 0.066 0.075               FULL BORE FLOW ESTABLISHED IN TEST PIPE.
2.0 0.07 0.015 1.0000 0.010 0.368 0.0125 0.042 0.047 0.013  0.38 5.411 0.037 0.047  0.010  0.064  0.063 -0.003 1.949 1.59
1.0 0.07 0.015 1.0000 0.006 0.226 0.0125 0.026 0.028 0.006  0.23 2.121 0.025 0.028  0.003  0.040  0.040 -0.000 0.765 1.13
8.0 0.07 0.015 1.0000 0.026 0.890 0.0100 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
6.0 0.07 0.015 1.0000 0.021 0.750 0.0100 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
4.0 0.07 0.015 1.0000 0.016 0.584 0.0100 0.066 0.075               FULL BORE FLOW ESTABLISHED IN TEST PIPE.
2.0 0.07 0.015 1.0000 0.010 0.368 0.0100 0.042 0.051 0.013  0.38 5.411 0.033 0.051  0.015  0.066  0.065 -0.001 2.009 1.48
1.0 0.07 0.015 1.0000 0.006 0.226 0.0100 0.026 0.030 0.006  0.23 2.121 0.023 0.030  0.008  0.040  0.040 -0.003 0.779 1.34
8.0 0.07 0.015 1.0000 0.026 0.890 0.0050 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
6.0 0.07 0.015 1.0000 0.021 0.750 0.0050 0.075 0.075               JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.
4.0 0.07 0.015 1.0000 0.016 0.584 0.0050 0.066 0.075               FULL BORE FLOW ESTABLISHED IN TEST PIPE.
2.0 0.07 0.015 1.0000 0.010 0.368 0.0050 0.042 0.068 0.013  0.38 5.411 0.024 0.063  0.044  0.089  0.076 -0.014 2.474 0.91
1.0 0.07 0.015 1.0000 0.006 0.226 0.0050 0.026 0.039 0.005  0.23 2.121 0.017 0.039  0.023  0.050  0.045 -0.005 0.909 0.57
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APPENDIX 5

JUMP LOCATION IN A 0.10 m WIDE RECTANGULAR CHANNEL, MANNING COEFFICIENT 0.015, AT SLOPES 1/40, 1/80, 1/100, 1/200

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 COMMON DATA  APPROACH PIPE DATA                               TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE   HN  TERM.  SLOPE   HC    HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)   M.  ENERGY (SIN)   M.    M.   DEPTH ENERGY F*N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F*N.  POS.
                               M.                       M.    M.    N.    M.     M.    M.      M.     M.     M.    M.    M.

8.0 0.10 0.015 0.0349 0.068 0.138 0.0250 0.087 0.078                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.10 0.015 0.0349 0.055 0.116 0.0250 0.072 0.062                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.0349 0.040 0.090 0.0250 0.055 0.046                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.0349 0.025 0.058 0.0250 0.034 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.0349 0.015 0.037 0.0250 0.022 0.017                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.0349 0.068 0.138 0.0125 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0349 0.055 0.116 0.0125 0.072 0.081 0.040  0.16 9.827 0.063 0.081  0.019  0.109  0.109 -0.000 7.675 1.339

4.0 0.10 0.015 0.0349 0.040 0.090 0.0125 0.055 0.059 0.030  0.12 5.767 0.050 0.059  0.009  0.083  0.083 -0.003 4.425 1.273

2.0 0.10 0.015 0.0349 0.025 0.058 0.0125 0.034 0.036 0.019  0.08 2.307 0.033 0.036  0.002  0.052  0.052 -0.000 1.745 1.043

1.0 0.10 0.015 0.0349 0.015 0.037 0.0125 0.022 0.022 0.012  0.05 0.917 0.022 0.022  0.000  0.033  0.033 -0.000 0.692 0.743

8.0 0.10 0.015 0.0349 0.068 0.138 0.0100 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.


6.0 0.10 0.015 0.0349 0.055 0.116 0.0100 0.072 0.089 0.040  0.16 9.827 0.056 0.089  0.033  0.114  0.112 -0.002 7.939 0.972

4.0 0.10 0.015 0.0349 0.040 0.090 0.0100 0.055 0.065 0.030  0.12 5.767 0.046 0.065  0.019  0.065  0.084 -0.001 4.526 0.759

2.0 0.10 0.015 0.0349 0.025 0.058 0.0100 0.034 0.039 0.019  0.08 2.307 0.031 0.039  0.008  0.052  0.052 -0.003 1.756 0.798

1.0 0.10 0.015 0.0349 0.015 0.037 0.0100 0.022 0.024 0.012  0.05 0.917 0.020 0.024  0.004  0.033  0.033 -0.000 0.697 0.546

8.0 0.10 0.015 0.0349 0.068 0.138 0.0050 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0349 0.055 0.116 0.0050 0.072 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.0349 0.040 0.090 0.0050 0.055 0.085 0.030  0.12 5.767 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 0.159

2.0 0.10 0.015 0.0349 0.025 0.058 0.0050 0.034 0.050 0.019  0.08 2.307 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 0.256

1.0 0.10 0.015 0.0349 0.015 0.037 0.0050 0.022 0.030 0.012  0.05 0.917 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.217
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 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                               M.                          M.    M.     N.    M.     M.    M.        M.   M.     M.     N.    M.

8.0 0.10 0.015 0.0698 0.052 0.172 0.0250 0.087 0.078            JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.042 0.145 0.0250 0.072 0.062            JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.0698 0.032 0.114 0.0250 0.055 0.046            JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.0698 0.019 0.073 0.0250 0.034 0.028            JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.0698 0.012 0.046 0.0250 0.022 0.017            JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.0698 0.052 0.172 0.0125 0.087 0.100            FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.042 0.145 0.0125 0.072 0.081 0.036  0.1810.747 0.063 0.081  0.019  0.109  0.109 -0.005 7.675 1.528

4.0 0.10 0.015 0.0698 0.032 0.114 0.0125 0.055 0.059 0.027  0.14 6.324 0.050 0.059  0.009  0.083  0.083 -0.000 4.425 1.524

2.0 0.10 0.015 0.0698 0.019 0.073 0.0125 0.034 0.036 0.017  0.09 2.533 0.033 0.036  0.002  0.052  0.052 -0.006 1.745 1.235

1.0 0.10 0.015 0.0698 0.012 0.046 0.0125 0.022 0.022 0.011  0.06 1.004 0.022 0.022  0.000  0.033  0.033 -0.005 0.692 0.935

8.0 0.10 0.015 0.0698 0.052 0.172 0.0100 0.087 0.100            FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.042 0.145 0.0100 0.072 0.089 0.036  0.1810.747 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 1.263

4.0 0.10 0.015 0.0698 0.032 0.114 0.0100 0.055 0.065 0.027  0.14 6.324 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 1.236

2.0 0.10 0.015 0.0698 0.019 0.073 0.0100 0.034 0.039 0.017  0.09 2.533 0.031 0.039  0.008  0.052  0.052 -0.000 1.766 0.944

1.0 0.10 0.015 0.0698 0.012 0.046 0.0100 0.022 0.024 0.011  0.06 1.004 0.020 0.024  0.004  0.033  0.033 -0.000 0.697 0.636

8.0 0.10 0.015 0.0698 0.052 0.172 0.0050 0.087 0.100            FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.0698 0.042 0.145 0.0050 0.072 0.100            FULL BORE FLOW ESTABLISHED IN TEST PIPE.



4.0 0.10 0.015 0.0698 0.032 0.114 0.0050 0.055 0.085 0.027  0.14 6.324 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 0.393

2.0 0.10 0.015 0.0698 0.019 0.073 0.0050 0.034 0.050 0.017  0.09 2.533 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 0.412

1.0 0.10 0.015 0.0698 0.012 0.046 0.0050 0.022 0.030 0.011  0.06 1.004 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.305
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 COMMON DATA  APPROACH PIPE DATA                            TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.M.  POS.
                                M.                           M.    M.    N.    M.     M.    M.      M.    M.     M.    N.    M.

8.0 0.10 0.015 0.1045 0.045 0.206 0.0250 0.087 0.078              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.036 0.175 0.0250 0.072 0.062              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.1045 0.027 0.137 0.0250 0.055 0.046              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.1045 0.017 0.087 0.0250 0.034 0.028              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.1045 0.011 0.054 0.0250 0.022 0.017              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.1045 0.045 0.206 0.0125 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.036 0.175 0.0125 0.072 0.081 0.032  0.2111.619 0.063 0.081  0.019  0.109  0.109 -0.003 7.675 1.557

4.0 0.10 0.015 0.1045 0.027 0.137 0.0125 0.055 0.059 0.024  0.16 6.841 0.050 0.059  0.009  0.083  0.083 -0.006 4.425 1.735

2.0 0.10 0.015 0.1045 0.017 0.087 0.0125 0.034 0.036 0.015  0.10 2.733 0.034 0.036  0.002  0.052  0.052 -0.003 1.745 1.317

1.0 0.10 0.015 0.1045 0.011 0.054 0.0125 0.022 0.022 0.010  0.06 1.079 0.022 0.022  0.000  0.033  0.033 -0.003 0.692 0.931

8.0 0.10 0.015 0.1045 0.045 0.206 0.0100 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.036 0.175 0.0100 0.072 0.089 0.032  0.2111.619 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 1.485

4.0 0.10 0.015 0.1045 0.027 0.137 0.0100 0.055 0.065 0.024  0.16 6.841 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 1.384

2.0 0.10 0.015 0.1045 0.017 0.087 0.0100 0.034 0.039 0.015  0.10 2.733 0.031 0.039  0.008  0.052  0.052 -0.000 1.766 1.053

1.0 0.10 0.015 0.1045 0.011 0.054 0.0100 0.022 0.024 0.010  0.06 1.079 0.020 0.024  0.004  0.033  0.033 -0.000 0.697 0.701

8.0 0.10 0.015 0.1045 0.045 0.206 0.0050 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.1045 0.036 0.175 0.0050 0.072 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.1045 0.027 0.137 0.0050 0.055 0.085 0.024  0.16 6.841 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 0.552

2.0 0.10 0.015 0.1045 0.017 0.087 0.0050 0.034 0.050 0.015  0.10 2.733 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 0.513

1.0 0.10 0.015 0.1045 0.011 0.054 0.0050 0.022 0.030 0.010  0.06 1.079 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.357
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 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE     HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.   ENERGY (SIN)     M.     M.   DEPTH ENERGY F.M  DEPTH  JEPTH CHANGE UPJUMP DOWN  CHANGE F.M.  POS.
                                M.                            M.    M.    N.    M.     M.    M.      M.    M.     M.     N.    M.

 8.0 0.10 0.015 0.1736 0.037 0.271 0.0250 0.087 0.078             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.10 0.015 0.1736 0.030 0.229 0.0250 0.072 0.062             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.1736 0.023 0.178 0.0250 0.055 0.046             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.1736 0.014 0.113 0.0250 0.034 0.028             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.1736 0.009 0.070 0.0250 0.022 0.017             JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.1736 0.037 0.271 0.0125 0.087 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.1736 0.030 0.229 0.0125 0.072 0.081 0.028  0.2613.111 0.063 0.081  0.019  0.109  0.109 -0.000 7.675 2.159

 4.0 0.10 0.015 0.1736 0.023 0.178 0.0125 0.055 0.059 0.021  0.20 7.699 0.050 0.059  0.009  0.083  0.083 -0.006 4.425 1.938

 2.0 0.10 0.015 0.1736 0.014 0.113 0.0125 0.034 0.036 0.013  0.13 3.064 0.034 0.036  0.002  0.052  0.052 -0.000 1.745 1.453

 1.0 0.10 0.015 0.1736 0.009 0.070 0.0125 0.022 0.022 0.007  0.08 1.204 0.022 0.022  0.000  0.033  0.033 -0.000 0.692 0.385

 8.0 0.10 0.015 0.1736 0.037 0.271 0.0100 0.087 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.1736 0.030 0.229 0.0100 0.072 0.089 0.028  0.2613.111 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 1.783

 4.0 0.10 0.015 0.1736 0.023 0.178 0.0100 0.055 0.065 0.021  0.20 7.699 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 1.619

 2.0 0.10 0.015 0.1736 0.014 0.113 0.0100 0.034 0.039 0.013  0.13 3.064 0.031 0.039  0.008  0.052  0.052 -0.003 1.766 1.137

 1.0 0.10 0.015 0.1736 0.009 0.070 0.0100 0.022 0.024 0.009  0.08 1.204 0.020 0.024  0.004  0.033  0.033 -0.000 0.697 0.783

 8.0 0.10 0.015 0.1736 0.037 0.271 0.0050 0.087 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.1736 0.030 0.229 0.0050 0.072 0.100             FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.1736 0.023 0.178 0.0050 0.055 0.085 0.021  0.20 7.699 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 0.737

 2.0 0.10 0.015 0.1736 0.014 0.113 0.0050 0.034 0.050 0.013  0.13 3.064 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 0.555

 1.0 0.10 0.015 0.1736 0.009 0.070 0.0050 0.022 0.030 0.009  0.08 1.204 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.443
```

```
COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN   TERM.   SLOPE    HC     HN   ENTRY  ENTRY ENTRY UPJUMP JUMN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.    COEFF  (SIN)    M.   ENERGY  (SIN)    M.     M.   DEPTH  ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                  M.                           M.     M.     N.    M.     M.     M.     M.     M.     M.     N.    M.

8.0 0.10 0.015 0.3402 0.029 0.408 0.0250 0.087 0.078                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.10 0.015 0.3402 0.024 0.342 0.0250 0.072 0.062                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.


4.0 0.10 0.015 0.3402 0.018 0.263 0.0250 0.055 0.046                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.3402 0.012 0.164 0.0250 0.034 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.3402 0.007 0.100 0.0250 0.022 0.017                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.3402 0.029 0.408 0.0125 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.3402 0.024 0.342 0.0125 0.072 0.081 0.023  0.3615.798 0.063 0.081  0.019  0.109  0.109 -0.000 7.675 2.559

4.0 0.10 0.015 0.3402 0.018 0.263 0.0125 0.055 0.059 0.013  0.28 9.240 0.050 0.059  0.009  0.083  0.083 -0.000 4.425 2.240

2.0 0.10 0.015 0.3402 0.012 0.164 0.0125 0.034 0.036 0.011  0.18 3.651 0.034 0.036  0.002  0.052  0.052 -0.000 1.745 1.544

1.0 0.10 0.015 0.3402 0.007 0.100 0.0125 0.022 0.022 0.007  0.11 1.420 0.022 0.022  0.000  0.033  0.033 -0.000 0.692 1.393

8.0 0.10 0.015 0.3402 0.029 0.408 0.0100 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.3402 0.024 0.342 0.0100 0.072 0.089 0.023  0.3615.798 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 2.133

4.0 0.10 0.015 0.3402 0.018 0.263 0.0100 0.055 0.065 0.013  0.28 9.240 0.046 0.059  0.019  0.085  0.084 -0.001 4.526 1.912

2.0 0.10 0.015 0.3402 0.012 0.164 0.0100 0.034 0.039 0.011  0.19 3.651 0.031 0.039  0.008  0.052  0.052 -0.000 1.756 1.375

1.0 0.10 0.015 0.3402 0.007 0.100 0.0100 0.022 0.024 0.007  0.11 1.420 0.020 0.024  0.004  0.033  0.033 -0.003 0.697 0.391

8.0 0.10 0.015 0.3402 0.029 0.408 0.0050 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.3402 0.024 0.342 0.0050 0.072 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.3402 0.018 0.263 0.0050 0.055 0.085 0.013  0.28 9.240 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 1.378

2.0 0.10 0.015 0.3402 0.012 0.164 0.0050 0.034 0.050 0.011  0.19 3.651 0.023 0.050  0.027  0.062  0.056 -0.006 2.015 0.931

1.0 0.10 0.015 0.3402 0.007 0.100 0.0050 0.022 0.030 0.007  0.11 1.420 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.557
```

```
 COMMON DATA  APPROACH PIPE DATA                               TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN  CHANGE F.N.  POS.
                                M.                          M.    M.    M.    M.     M.    M.      M.     M.    M.     M.    M.


 8.0 0.10 0.015 0.5000 0.026 0.521 0.0250 0.087 0.078                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.021 0.434 0.0250 0.072 0.062                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.5000 0.016 0.333 0.0250 0.055 0.046                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.5000 0.010 0.206 0.0250 0.034 0.028                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.5000 0.007 0.125 0.0250 0.022 0.017                     JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.5000 0.026 0.521 0.0125 0.087 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.021 0.434 0.0125 0.072 0.081 0.021  0.4517.715 0.063 0.081  0.019  0.109  0.109 -0.006 7.675 2.755



 4.0 0.10 0.015 0.5000 0.016 0.333 0.0125 0.055 0.059 0.016  0.3510.337 0.050 0.059  0.009  0.083  0.083 -0.003 4.425 2.394

 2.0 0.10 0.015 0.5000 0.010 0.206 0.0125 0.034 0.036 0.010  0.22 4.071 0.034 0.036  0.002  0.052  0.052 -0.006 1.745 1.735

 1.0 0.10 0.015 0.5000 0.007 0.125 0.0125 0.022 0.022 0.006  0.13 1.566 0.022 0.022  0.000  0.033  0.033 -0.003 0.692 1.143

 8.0 0.10 0.015 0.5000 0.026 0.521 0.0100 0.087 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.021 0.434 0.0100 0.072 0.089 0.021  0.4517.715 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 2.394

 4.0 0.10 0.015 0.5000 0.016 0.333 0.0100 0.055 0.065 0.016  0.3510.337 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 2.055

 2.0 0.10 0.015 0.5000 0.010 0.206 0.0100 0.034 0.039 0.010  0.22 4.071 0.031 0.039  0.008  0.052  0.052 -0.000 1.766 1.457

 1.0 0.10 0.015 0.5000 0.007 0.125 0.0100 0.022 0.024 0.006  0.13 1.566 0.020 0.024  0.004  0.033  0.033 -0.003 0.697 0.942

 8.0 0.10 0.015 0.5000 0.026 0.521 0.0050 0.087 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.5000 0.021 0.434 0.0050 0.072 0.100                     FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.5000 0.016 0.333 0.0050 0.055 0.085 0.016  0.3510.337 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 1.232

 2.0 0.10 0.015 0.5000 0.010 0.206 0.0050 0.034 0.050 0.010  0.22 4.071 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 0.921

 1.0 0.10 0.015 0.5000 0.007 0.125 0.0050 0.022 0.030 0.006  0.13 1.566 0.015 0.030  0.015  0.038  0.031 -0.002 0.775 0.534
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```
COMMON DATA  APPROACH PIPE DATA                               TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN   TERM.  SLOPE    HC      HN   ENTRY ENTRY ENTRY UPJUMP JUMN  DEPTH  ENERGY ENERGY ENERGY JUMP   JUMP
L/S   M.    COEFF  (SIN)    M.   ENERGY (SIN)    M.      M.   DEPTH ENERGY F*M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F*M.   POS.
                                  M.                          M.    M.     N.    M.     M.     M.     M.     M.     M.     N.    M.

8.0 0.10 0.015 0.7070 0.023 0.651 0.0250 0.087 0.078                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

5.0 0.10 0.015 0.7070 0.019 0.541 0.0250 0.072 0.062                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 0.7070 0.014 0.412 0.0250 0.055 0.046                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 0.7070 0.009 0.254 0.0250 0.034 0.028                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 0.7070 0.006 0.153 0.0250 0.022 0.017                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 0.7070 0.023 0.651 0.0125 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.7070 0.019 0.541 0.0125 0.072 0.081 0.013  0.5619.720 0.063 0.081  0.019  0.109  0.109 -0.003 7.675 2.935

4.0 0.10 0.015 0.7070 0.014 0.412 0.0125 0.055 0.059 0.014  0.4311.471 0.050 0.059  0.009  0.083  0.083 -0.003 4.425 2.521

2.0 0.10 0.015 0.7070 0.009 0.254 0.0125 0.034 0.036 0.009  0.26 4.504 0.034 0.035  0.002  0.052  0.052 -0.003 1.745 1.311

1.0 0.10 0.015 0.7070 0.006 0.153 0.0125 0.022 0.022 0.006  0.16 1.749 0.022 0.022  0.000  0.033  0.033 -0.003 0.692 1.187

8.0 0.10 0.015 0.7070 0.023 0.651 0.0100 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.7070 0.019 0.541 0.0100 0.072 0.089 0.013  0.5619.720 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 2.552

4.0 0.10 0.015 0.7070 0.014 0.412 0.0100 0.055 0.065 0.014  0.4311.471 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 2.133


2.0 0.10 0.015 0.7070 0.009 0.254 0.0100 0.034 0.039 0.009  0.26 4.504 0.031 0.039  0.008  0.052  0.052 -0.003 1.756 1.561

1.0 0.10 0.015 0.7070 0.006 0.153 0.0100 0.022 0.024 0.006  0.16 1.749 0.020 0.024  0.004  0.033  0.033 -0.003 0.697 0.935

8.0 0.10 0.015 0.7070 0.023 0.651 0.0050 0.087 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 0.7070 0.019 0.541 0.0050 0.072 0.100                  FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 0.7070 0.014 0.412 0.0050 0.055 0.085 0.014  0.4311.471 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 1.354

2.0 0.10 0.015 0.7070 0.009 0.254 0.0050 0.034 0.050 0.009  0.26 4.504 0.023 0.050  0.027  0.062  0.056 -0.006 2.015 0.935

1.0 0.10 0.015 0.7070 0.006 0.153 0.0050 0.022 0.030 0.006  0.16 1.749 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.545
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```
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA.  MANN. SLOPE   HN   TERM.  SLOPE   HC    HN   ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.    COEFF (SIN)   M.   ENERGY (SIN)   M.    M.   DEPTH ENERGY F.M. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.M.  POS.
                              M.                        M.    M.     M.   M.     M.    M.     M.     M.     M.     M.    M.

 8.0 0.10 0.015 0.8660 0.021 0.743 0.0250 0.087 0.078              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.10 0.015 0.8660 0.018 0.615 0.0250 0.072 0.062              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.8660 0.013 0.468 0.0250 0.055 0.046              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.8660 0.009 0.287 0.0250 0.034 0.028              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.8660 0.006 0.172 0.0250 0.022 0.017              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.8660 0.021 0.743 0.0125 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.8660 0.018 0.615 0.0125 0.072 0.081 0.017  0.6320.996 0.063 0.081  0.019  0.109  0.109 -0.000 7.675 3.325

 4.0 0.10 0.015 0.8660 0.013 0.468 0.0125 0.055 0.059 0.013  0.4812.206 0.050 0.059  0.009  0.083  0.083 -0.000 4.425 2.539

 2.0 0.10 0.015 0.8660 0.009 0.287 0.0125 0.034 0.036 0.003  0.30 4.784 0.034 0.036  0.002  0.052  0.052 -0.003 1.745 1.932

 1.0 0.10 0.015 0.8660 0.006 0.172 0.0125 0.022 0.022 0.005  0.18 1.854 0.022 0.022  0.000  0.033  0.033 -0.003 0.692 1.213

 8.0 0.10 0.015 0.8660 0.021 0.743 0.0100 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.8660 0.018 0.615 0.0100 0.072 0.089 0.017  0.6320.996 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 2.542

 4.0 0.10 0.015 0.8660 0.013 0.468 0.0100 0.055 0.065 0.013  0.4912.206 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 2.259

 2.0 0.10 0.015 0.8660 0.009 0.287 0.0100 0.034 0.039 0.003  0.30 4.784 0.031 0.039  0.009  0.052  0.052 -0.000 1.766 1.581

 1.0 0.10 0.015 0.8660 0.006 0.172 0.0100 0.022 0.024 0.005  0.18 1.854 0.020 0.024  0.004  0.033  0.033 -0.006 0.697 1.313

 8.0 0.10 0.015 0.8660 0.021 0.743 0.0050 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.8660 0.018 0.615 0.0050 0.072 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.8660 0.013 0.468 0.0050 0.055 0.085 0.013  0.4812.208 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 1.423



 2.0 0.10 0.015 0.8660 0.009 0.287 0.0050 0.034 0.050 0.003  0.30 4.784 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 1.336

 1.0 0.10 0.015 0.8660 0.006 0.172 0.0050 0.022 0.030 0.005  0.18 1.854 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.557
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC      HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)    M.   ENERGY (SIN)    M.      M.  DEPTH ENERGY F.N.  DEPTH DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                M.                         M.    M.    N.    M.    M.    M.       M.    M.     M.    N.    M.

 8.0 0.10 0.015 0.9659 0.020 0.797 0.0250 0.087 0.078                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.10 0.015 0.9659 0.017 0.661 0.0250 0.072 0.062                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.10 0.015 0.9659 0.013 0.501 0.0250 0.055 0.046                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.10 0.015 0.9659 0.008 0.307 0.0250 0.034 0.028                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.10 0.015 0.9659 0.005 0.184 0.0250 0.022 0.017                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.10 0.015 0.9659 0.020 0.797 0.0125 0.087 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.9659 0.017 0.661 0.0125 0.072 0.081 0.017  0.6821.738 0.063 0.081  0.019  0.109  0.109 -0.000 7.675 3.073

 4.0 0.10 0.015 0.9659 0.013 0.501 0.0125 0.055 0.059 0.013  0.5112.620 0.050 0.059  0.009  0.083  0.083 -0.000 4.425 2.526

 2.0 0.10 0.015 0.9659 0.008 0.307 0.0125 0.034 0.036 0.008  0.32 4.943 0.034 0.035  0.002  0.052  0.052 -0.000 1.745 1.373

 1.0 0.10 0.015 0.9659 0.005 0.184 0.0125 0.022 0.022 0.005  0.19 1.915 0.022 0.022  0.000  0.033  0.033 -0.000 0.692 1.222

 8.0 0.10 0.015 0.9659 0.020 0.797 0.0100 0.087 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.9659 0.017 0.661 0.0100 0.072 0.089 0.017  0.6821.738 0.057 0.089  0.033  0.114  0.112 -0.002 7.939 2.530

 4.0 0.10 0.015 0.9659 0.013 0.501 0.0100 0.055 0.065 0.013  0.5112.620 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 2.292

 2.0 0.10 0.015 0.9659 0.008 0.307 0.0100 0.034 0.039 0.008  0.32 4.943 0.031 0.039  0.008  0.052  0.052 -0.000 1.766 1.631

 1.0 0.10 0.015 0.9659 0.005 0.184 0.0100 0.022 0.024 0.005  0.19 1.915 0.020 0.024  0.004  0.033  0.033 -0.000 0.697 1.322

 8.0 0.10 0.015 0.9659 0.020 0.797 0.0050 0.087 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 6.0 0.10 0.015 0.9659 0.017 0.661 0.0050 0.072 0.100                 FULL BORE FLOW ESTABLISHED IN TEST PIPE.

 4.0 0.10 0.015 0.9659 0.013 0.501 0.0050 0.055 0.085 0.013  0.5112.620 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 1.455

 2.0 0.10 0.015 0.9659 0.008 0.307 0.0050 0.034 0.050 0.008  0.32 4.943 0.023 0.050  0.027  0.062  0.058 -0.004 2.615 1.357

 1.0 0.10 0.015 0.9659 0.005 0.184 0.0050 0.022 0.030 0.005  0.19 1.915 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.531
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```
COMMON DATA  APPROACH PIPE DATA                            TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.    COEFF  (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N.  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                   M.                          M.    M.    N.     M.     M.    M.      M.     M.     M.    N.    M.

8.0 0.10 0.015 1.0000 0.020 0.816 0.0250 0.087 0.078              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.10 0.015 1.0000 0.017 0.676 0.0250 0.072 0.062              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.10 0.015 1.0000 0.013 0.512 0.0250 0.055 0.046              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.10 0.015 1.0000 0.008 0.313 0.0250 0.034 0.028              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.10 0.015 1.0000 0.005 0.188 0.0250 0.022 0.017              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.10 0.015 1.0000 0.020 0.816 0.0125 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 1.0000 0.017 0.676 0.0125 0.072 0.081 0.016  0.6921.979 0.063 0.081  0.019  0.109  0.109 -0.000 7.675 3.033

4.0 0.10 0.015 1.0000 0.013 0.512 0.0125 0.055 0.059 0.013  0.5212.756 0.050 0.059  0.009  0.083  0.083 -0.000 4.425 2.533

2.0 0.10 0.015 1.0000 0.008 0.313 0.0125 0.034 0.036 0.008  0.32 4.991 0.034 0.036  0.002  0.052  0.052 -0.000 1.745 1.379

1.0 0.10 0.015 1.0000 0.005 0.188 0.0125 0.022 0.022 0.005  0.19 1.934 0.022 0.022  0.000  0.033  0.033 -0.000 0.692 1.225

8.0 0.10 0.015 1.0000 0.020 0.816 0.0100 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 1.0000 0.017 0.676 0.0100 0.072 0.089 0.016  0.6921.979 0.057 0.089  0.033  0.114  0.112 -0.002 7.439 2.733

4.0 0.10 0.015 1.0000 0.013 0.512 0.0100 0.055 0.065 0.013  0.5212.756 0.046 0.065  0.019  0.085  0.084 -0.001 4.526 2.303

2.0 0.10 0.015 1.0000 0.008 0.313 0.0100 0.034 0.039 0.008  0.32 4.991 0.031 0.039  0.008  0.052  0.052 -0.000 1.766 1.507

1.0 0.10 0.015 1.0000 0.005 0.188 0.0100 0.022 0.024 0.005  0.19 1.934 0.020 0.024  0.004  0.033  0.033 -0.000 0.697 1.325

8.0 0.10 0.015 1.0000 0.020 0.816 0.0050 0.087 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

6.0 0.10 0.015 1.0000 0.017 0.676 0.0050 0.072 0.100              FULL BORE FLOW ESTABLISHED IN TEST PIPE.

4.0 0.10 0.015 1.0000 0.013 0.512 0.0050 0.055 0.085 0.013  0.5212.756 0.033 0.085  0.052  0.109  0.096 -0.013 5.427 1.457

2.0 0.10 0.015 1.0000 0.008 0.313 0.0050 0.034 0.050 0.008  0.32 4.991 0.023 0.050  0.027  0.062  0.058 -0.004 2.015 1.353

1.0 0.10 0.015 1.0000 0.005 0.188 0.0050 0.022 0.030 0.005  0.19 1.934 0.015 0.030  0.015  0.038  0.036 -0.002 0.775 0.684
```

APPENDIX 6

JUMP LOCATION IN A 0.15 m WIDE RECTANGULAR CHANNEL, MANNING COEFFICIENT 0.015, AT SLOPES 1/60, 1/80, 1/100, 1/200

```
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN   TERM.  SLOPE   HC    HM   ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)   M.  ENERGY  (SIN)   M.    M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                M.                        M.    M.    N.    M.     M.     M.      M.     M.     M.    N.    M.

8.0 0.15 0.015 0.0349 0.046 0.115 0.0250 0.066 0.052              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.15 0.015 0.0349 0.038 0.095 0.0250 0.055 0.042              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.0349 0.028 0.073 0.0250 0.042 0.032              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.0349 0.018 0.046 0.0250 0.026 0.020              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.0349 0.012 0.029 0.0250 0.017 0.013              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.0349 0.046 0.115 0.0125 0.066 0.067 0.036  0.1512.933 0.066 0.067  0.000  0.099  0.099 -0.000 9.670 2.517

6.0 0.15 0.015 0.0349 0.038 0.095 0.0125 0.055 0.054              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.0349 0.028 0.073 0.0125 0.042 0.040              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.0349 0.018 0.046 0.0125 0.026 0.025              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.0349 0.012 0.029 0.0125 0.017 0.016              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.0349 0.046 0.115 0.0100 0.066 0.072 0.036  0.1512.933 0.061 0.072  0.012  0.100  0.100 -0.003 9.746 1.883


6.0 0.15 0.015 0.0349 0.038 0.095 0.0100 0.055 0.058 0.029  0.12 8.836 0.051 0.058  0.007  0.082  0.082 -0.000 6.620 1.693

4.0 0.15 0.015 0.0349 0.028 0.073 0.0100 0.042 0.044 0.022  0.10 5.160 0.040 0.044  0.004  0.063  0.063 -0.000 3.846 1.432

2.0 0.15 0.015 0.0349 0.018 0.046 0.0100 0.026 0.027 0.014  0.06 2.045 0.025 0.027  0.002  0.039  0.039 -0.000 1.525 0.333

1.0 0.15 0.015 0.0349 0.012 0.029 0.0100 0.017 0.017 0.009  0.04 0.807 0.016 0.017  0.001  0.025  0.025 -0.000 0.605 0.517

8.0 0.15 0.015 0.0349 0.046 0.115 0.0050 0.066 0.094 0.036  0.1512.933 0.045 0.094  0.049  0.118  0.110 -0.00711.037 0.681

6.0 0.15 0.015 0.0349 0.038 0.095 0.0050 0.055 0.076 0.029  0.12 8.836 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 0.671

4.0 0.15 0.015 0.0349 0.028 0.073 0.0050 0.042 0.056 0.022  0.10 5.160 0.030 0.056  0.026  0.070  0.068 -0.003 4.212 0.596

2.0 0.15 0.015 0.0349 0.018 0.046 0.0050 0.026 0.034 0.014  0.06 2.045 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 0.435

1.0 0.15 0.015 0.0349 0.012 0.029 0.0050 0.017 0.022 0.009  0.04 0.807 0.012 0.022  0.009  0.027  0.026 -0.001 0.652 0.237
```

```
COMMON DATA  APPROACH PIPE DATA                         TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC      HN   ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.  ENERGY  (SIN)    M.      M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                              M.    M.    N.    M.     M.    M.      M.     M.     M.     N.    M.

8.0 0.15 0.015 0.0698 0.036 0.148 0.0250 0.066 0.052                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.15 0.015 0.0698 0.030 0.123 0.0250 0.055 0.042                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.0698 0.023 0.094 0.0250 0.042 0.032                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.0698 0.014 0.058 0.0250 0.026 0.020                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.0698 0.009 0.036 0.0250 0.017 0.013                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.0698 0.036 0.148 0.0125 0.066 0.067 0.031  0.1814.344 0.066 0.067  0.000  0.099  0.099 -0.006 9.670 3.333

6.0 0.15 0.015 0.0698 0.030 0.123 0.0125 0.055 0.054                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.0698 0.023 0.094 0.0125 0.042 0.040                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.0698 0.014 0.058 0.0125 0.026 0.025                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.0698 0.009 0.036 0.0125 0.017 0.016                JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.0698 0.036 0.148 0.0100 0.066 0.072 0.031  0.1814.344 0.061 0.072  0.012  0.100  0.100 -0.006 9.746 2.233

6.0 0.15 0.015 0.0698 0.030 0.123 0.0100 0.055 0.058 0.026  0.15 9.796 0.051 0.058  0.007  0.082  0.082 -0.003 6.620 2.333

4.0 0.15 0.015 0.0698 0.023 0.094 0.0100 0.042 0.044 0.023  0.11 5.706 0.040 0.044  0.004  0.063  0.063 -0.003 3.646 1.533

2.0 0.15 0.015 0.0698 0.014 0.058 0.0100 0.026 0.027 0.012  0.07 2.251 0.025 0.027  0.002  0.039  0.039 -0.000 1.525 1.334

1.0 0.15 0.015 0.0698 0.009 0.035 0.0100 0.017 0.017 0.003  0.04 0.883 0.016 0.017  0.001  0.025  0.025 -0.000 0.605 0.537

8.0 0.15 0.015 0.0698 0.036 0.148 0.0050 0.066 0.094 0.031  0.1814.344 0.045 0.094  0.049  0.118  0.110 -0.00711.037 1.333

6.0 0.15 0.015 0.0698 0.030 0.123 0.0050 0.055 0.076 0.026  0.15 9.796 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 3.753


4.0 0.15 0.015 0.0698 0.023 0.094 0.0050 0.042 0.056 0.023  0.11 5.706 0.030 0.056  0.026  0.070  0.069 -0.003 4.212 0.911

2.0 0.15 0.015 0.0698 0.014 0.058 0.0050 0.026 0.034 0.012  0.07 2.251 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 0.583

1.0 0.15 0.015 0.0698 0.009 0.036 0.0050 0.017 0.022 0.003  0.04 0.883 0.012 0.022  0.009  0.027  0.026 -0.001 0.652 0.305
```

```
 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 J.   DIA.  MANN. SLOPE    HN   TERM.  SLOPE     HC     HM   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.    COEFF (SIN)    M.  ENERGY  (SIN)     M.     M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                 M.                           M.    M.    N.    M.     M.     M.      M.     M.     M.     N.    M.

8.0 0.15 0.015 0.1045 0.031 0.179 0.0250 0.066 0.052                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
6.0 0.15 0.015 0.1045 0.026 0.148 0.0250 0.055 0.042                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
4.0 0.15 0.015 0.1045 0.020 0.113 0.0250 0.042 0.032                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
2.0 0.15 0.015 0.1045 0.013 0.069 0.0250 0.026 0.020                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
1.0 0.15 0.015 0.1045 0.008 0.042 0.0250 0.017 0.013                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
8.0 0.15 0.015 0.1045 0.031 0.179 0.0125 0.066 0.067 0.028  0.2115.578 0.066 0.067  0.000  0.099  0.099 -0.066 9.670 3.250
6.0 0.15 0.015 0.1045 0.026 0.148 0.0125 0.055 0.054                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
4.0 0.15 0.015 0.1045 0.020 0.113 0.0125 0.042 0.040                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
2.0 0.15 0.015 0.1045 0.013 0.069 0.0125 0.026 0.025                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
1.0 0.15 0.015 0.1045 0.008 0.042 0.0125 0.017 0.016                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
8.0 0.15 0.015 0.1045 0.031 0.179 0.0100 0.066 0.072 0.023  0.2115.578 0.061 0.072  0.012  0.100  0.100 -0.006 9.746 2.535
6.0 0.15 0.015 0.1045 0.026 0.148 0.0100 0.055 0.058 0.023  0.1710.630 0.051 0.058  0.007  0.082  0.082 -0.003 6.620 2.233
4.0 0.15 0.015 0.1045 0.020 0.113 0.0100 0.042 0.044 0.013  0.13 6.182 0.040 0.044  0.004  0.063  0.063 -0.003 3.646 1.793
2.0 0.15 0.015 0.1045 0.013 0.069 0.0100 0.026 0.027 0.011  0.09 2.429 0.025 0.027  0.002  0.039  0.039 -0.003 1.525 1.123
1.0 0.15 0.015 0.1045 0.008 0.042 0.0100 0.017 0.017 0.007  0.05 0.949 0.016 0.017  0.001  0.025  0.025 -0.003 0.605 0.533
8.0 0.15 0.015 0.1045 0.031 0.179 0.0050 0.066 0.094 0.028  0.2115.578 0.045 0.094  0.049  0.118  0.110 -0.00711.037 1.273
6.0 0.15 0.015 0.1045 0.026 0.148 0.0050 0.055 0.076 0.023  0.1710.630 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 1.155
4.0 0.15 0.015 0.1045 0.020 0.113 0.0050 0.042 0.056 0.018  0.13 6.182 0.030 0.056  0.026  0.070  0.068 -0.003 4.212 0.737
2.0 0.15 0.015 0.1045 0.013 0.069 0.0050 0.026 0.034 0.011  0.09 2.429 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 0.516
1.0 0.15 0.015 0.1045 0.008 0.042 0.0050 0.017 0.022 0.007  0.05 0.949 0.012 0.022  0.004  0.027  0.026 -0.001 0.652 0.353
```

```
 COMMON DATA  APPROACH PIPE DATA                             TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC      HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.      M.  DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                               M.                          M.    M.    N.    M.     M.    M.      M.    M.     M.    N.    %.

 8.0 0.15 0.015 0.1736 0.026 0.234 0.0250 0.066 0.052                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.1736 0.022 0.193 0.0250 0.055 0.042                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.1736 0.017 0.146 0.0250 0.042 0.032                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.1736 0.011 0.089 0.0250 0.026 0.020                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.1736 0.007 0.054 0.0250 0.017 0.013                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.1736 0.026 0.234 0.0125 0.065 0.067 0.025  0.2617.582 0.066 0.067  0.000  0.099  0.099 -0.003 9.670 3.592
 6.0 0.15 0.015 0.1736 0.022 0.193 0.0125 0.055 0.054                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.1736 0.017 0.146 0.0125 0.042 0.040                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.1736 0.011 0.089 0.0125 0.026 0.025                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.1736 0.007 0.054 0.0125 0.017 0.016                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.1736 0.026 0.234 0.0100 0.066 0.072 0.025  0.2617.582 0.061 0.072  0.012  0.100  0.100 -0.003 9.796 2.920
 6.0 0.15 0.015 0.1736 0.022 0.193 0.0100 0.055 0.058 0.021  0.2111.979 0.051 0.053  0.007  0.082  0.082 -0.003 6.620 2.671
 4.0 0.15 0.015 0.1736 0.017 0.146 0.0100 0.042 0.044 0.016  0.16 6.947 0.040 0.044  0.004  0.063  0.063 -0.003 3.846 1.370
 2.0 0.15 0.015 0.1736 0.011 0.089 0.0100 0.026 0.027 0.013  0.10 2.719 0.026 0.027  0.002  0.034  0.033 -0.003 1.525 1.235
 1.0 0.15 0.015 0.1736 0.007 0.054 0.0100 0.017 0.017 0.007  0.06 1.056 0.016 0.017  0.001  0.025  0.025 -0.003 0.605 0.731
 8.0 0.15 0.015 0.1736 0.026 0.234 0.0050 0.066 0.094 0.025  0.2617.582 0.045 0.094  0.049  0.118  0.113 -0.00711.037 1.542
 5.0 0.15 0.015 0.1736 0.022 0.193 0.0050 0.055 0.076 0.021  0.2111.979 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 1.411
 4.0 0.15 0.015 0.1736 0.017 0.146 0.0050 0.042 0.056 0.016  0.16 6.947 0.030 0.055  0.026  0.070  0.068 -0.003 4.212 1.144
 2.0 0.15 0.015 0.1736 0.011 0.089 0.0050 0.026 0.034 0.010  0.10 2.719 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 5.722
 1.0 0.15 0.015 0.1736 0.007 0.054 0.0050 0.017 0.022 0.007  0.06 1.056 0.012 0.022  0.009  0.027  0.026 -0.001 0.652 0.913
 COMMON DATA  APPROACH PIPE DATA                        TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE   HN   TERM.  SLOPE    HC    HN   ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)   M.   ENERGY (SIN)    M.    M.   DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                             M.                          M.    M.    N.    M.     M.    M.     M.     M.     M.     N.    M.

8.0 0.15 0.015 0.3402 0.021 0.345 0.0250 0.066 0.052              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.
6.0 0.15 0.015 0.3402 0.018 0.283 0.0250 0.055 0.042              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.


4.0 0.15 0.015 0.3402 0.014 0.212 0.0250 0.042 0.032              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.
2.0 0.15 0.015 0.3402 0.009 0.128 0.0250 0.026 0.020              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPF.
1.0 0.15 0.015 0.3402 0.006 0.076 0.0250 0.017 0.013              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.
8.0 0.15 0.015 0.3402 0.021 0.345 0.0125 0.066 0.067 0.023  0.3721.131 0.066 0.067  0.000  0.099  0.099 -0.000 9.670 3.331
6.0 0.15 0.015 0.3402 0.018 0.283 0.0125 0.055 0.054              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.
4.0 0.15 0.015 0.3402 0.014 0.212 0.0125 0.042 0.040              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.
2.0 0.15 0.015 0.3402 0.009 0.128 0.0125 0.026 0.025              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.
1.0 0.15 0.015 0.3402 0.006 0.076 0.0125 0.017 0.016              JUMP IMPOSSIBLE AS HNCHC IN TEST PIPE.
8.0 0.15 0.015 0.3402 0.021 0.345 0.0100 0.066 0.072 0.023  0.3721.131 0.061 0.072  0.012  0.100  0.100 -0.003 9.746 3.223
6.0 0.15 0.015 0.3402 0.018 0.283 0.0100 0.055 0.058 0.017  0.3014.346 0.051 0.051  0.007  0.082  0.082 -0.003 6.620 2.792
4.0 0.15 0.015 0.3402 0.014 0.212 0.0100 0.042 0.044 0.013  0.23 3.284 0.040 0.044  0.004  0.063  0.053 -0.003 3.846 2.297
2.0 0.15 0.015 0.3402 0.009 0.128 0.0100 0.026 0.027 0.005  0.14 3.223 0.026 0.027  0.002  0.039  0.039 -0.003 1.525 1.371
1.0 0.15 0.015 0.3402 0.006 0.076 0.0100 0.017 0.017 0.005  0.08 1.245 0.016 0.017  0.001  0.025  0.025 -0.003 0.605 0.779
8.0 0.15 0.015 0.3402 0.021 0.345 0.0050 0.066 0.094 0.023  0.3721.131 0.045 0.094  0.049  0.118  0.113 -0.00711.037 1.372
6.0 0.15 0.015 0.3402 0.018 0.283 0.0050 0.055 0.076 0.017  0.3014.346 0.038 0.075  0.037  0.094  0.090 -0.005 7.374 1.725
4.0 0.15 0.015 0.3402 0.014 0.212 0.0050 0.042 0.056 0.013  0.23 3.284 0.030 0.056  0.026  0.070  0.068 -0.003 4.212 1.373
2.0 0.15 0.015 0.3402 0.009 0.128 0.0050 0.026 0.034 0.005  0.14 3.223 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 0.836
1.0 0.15 0.015 0.3402 0.006 0.076 0.0050 0.017 0.022 0.005  0.09 1.245 0.012 0.022  0.009  0.027  0.026 -0.001 0.652 0.433
```

```
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE   HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)   M.     M.  DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                         M.    M.    N.    M.     M.    M.        M.    M.     M.    N.    M.

 8.0 0.15 0.015 0.5000 0.019 0.435 0.0250 0.066 0.052                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 0.5000 0.015 0.356 0.0250 0.055 0.042                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 0.5000 0.012 0.266 0.0250 0.042 0.032                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.5000 0.008 0.160 0.0250 0.026 0.020                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.5000 0.005 0.095 0.0250 0.017 0.013                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.5000 0.019 0.435 0.0125 0.066 0.067 0.013  0.4523.619 0.066 0.067  0.000  0.099  0.099 -0.000 9.670 6.181

 6.0 0.15 0.015 0.5000 0.015 0.356 0.0125 0.055 0.054                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.


 4.0 0.15 0.015 0.5000 0.012 0.266 0.0125 0.042 0.040                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 0.5000 0.008 0.160 0.0125 0.026 0.025                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 0.5000 0.005 0.095 0.0125 0.017 0.016                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 0.5000 0.019 0.435 0.0100 0.066 0.072 0.018  0.4523.619 0.061 0.072  0.012  0.100  0.100 -0.000 9.766 3.425

 6.0 0.15 0.015 0.5000 0.015 0.356 0.0100 0.055 0.058 0.015  0.3716.020 0.051 0.053  0.007  0.082  0.082 -0.003 6.620 2.350

 4.0 0.15 0.015 0.5000 0.012 0.266 0.0100 0.042 0.044 0.012  0.28 9.236 0.040 0.044  0.004  0.063  0.063 -0.000 3.646 2.325

 2.0 0.15 0.015 0.5000 0.008 0.160 0.0100 0.026 0.027 0.008  0.17 3.582 0.026 0.027  0.002  0.039  0.039 -0.000 1.525 1.661

 1.0 0.15 0.015 0.5000 0.005 0.095 0.0100 0.017 0.017 0.005  0.10 1.380 0.016 0.017  0.001  0.025  0.025 -0.000 0.605 0.813

 8.0 0.15 0.015 0.5000 0.019 0.435 0.0050 0.066 0.094 0.013  0.4523.619 0.045 0.094  0.049  0.118  0.110 -0.00711.637 2.171

 6.0 0.15 0.015 0.5000 0.015 0.356 0.0050 0.055 0.076 0.015  0.3716.020 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 1.335

 4.0 0.15 0.015 0.5000 0.012 0.266 0.0050 0.042 0.056 0.012  0.28 9.236 0.030 0.056  0.026  0.070  0.068 -0.003 4.212 1.632

 2.0 0.15 0.015 0.5000 0.008 0.160 0.0050 0.026 0.034 0.008  0.17 3.582 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 0.926

 1.0 0.15 0.015 0.5000 0.005 0.095 0.0050 0.017 0.022 0.005  0.10 1.380 0.012 0.022  0.009  0.027  0.025 -0.001 0.652 0.523
```

```
COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE   HN  TERM.  SLOPE   HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)   M.  ENERGY (SIN)   M.     M.  DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F+M.  POS.
                             M.                         M.    M.    M.    M.     M.    M.     M.     M.     M.    M.    M.

8.0 0.15 0.015 0.7070 0.017 0.539 0.0250 0.066 0.052                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.15 0.015 0.7070 0.014 0.439 0.0250 0.055 0.042                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.7070 0.011 0.327 0.0250 0.042 0.032                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.7070 0.007 0.195 0.0250 0.026 0.020                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.7070 0.005 0.115 0.0250 0.017 0.013                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.7070 0.017 0.539 0.0125 0.066 0.067 0.016  0.5626.223 0.066 0.067  0.000  0.099  0.099 -0.003 9.670 4.305

6.0 0.15 0.015 0.7070 0.014 0.439 0.0125 0.055 0.054                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.7070 0.011 0.327 0.0125 0.042 0.040                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.7070 0.007 0.195 0.0125 0.026 0.025                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.7070 0.005 0.115 0.0125 0.017 0.016                 JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.7070 0.017 0.539 0.0100 0.066 0.072 0.016  0.5626.223 0.061 0.072  0.012  0.100  0.100 -0.006 9.746 3.531

6.0 0.15 0.015 0.7070 0.014 0.439 0.0100 0.055 0.058 0.014  0.4517.743 0.051 0.058  0.007  0.082  0.082 -0.006 6.620 3.335

4.0 0.15 0.015 0.7070 0.011 0.327 0.0100 0.042 0.044 0.011  0.3410.215 0.040 0.044  0.004  0.063  0.063 -0.003 3.646 2.422


2.0 0.15 0.015 0.7070 0.007 0.195 0.0100 0.026 0.027 0.007  0.20 1.950 0.026 0.027  0.002  0.039  0.039 -0.003 1.525 1.437

1.0 0.15 0.015 0.7070 0.005 0.115 0.0100 0.017 0.017 0.004  0.12 1.519 0.016 0.017  0.001  0.025  0.025 -0.003 0.605 0.351

8.0 0.15 0.015 0.7070 0.017 0.539 0.0050 0.066 0.094 0.016  0.5626.223 0.045 0.094  0.049  0.118  0.110 -0.00711.037 2.337

6.0 0.15 0.015 0.7070 0.014 0.439 0.0050 0.055 0.076 0.014  0.4517.743 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 2.316

4.0 0.15 0.015 0.7070 0.011 0.327 0.0050 0.042 0.056 0.011  0.3410.215 0.030 0.056  0.026  0.070  0.068 -0.003 4.212 1.533

2.0 0.15 0.015 0.7070 0.007 0.195 0.0050 0.026 0.034 0.007  0.20 1.950 0.020 0.036  0.015  0.043  0.042 -0.001 1.645 0.370

1.0 0.15 0.015 0.7070 0.005 0.115 0.0050 0.017 0.022 0.004  0.17 1.519 0.012 0.022  0.009  0.027  0.026 -0.001 0.652 0.553
```

```
  COMMON DATA  APPROACH PIPE DATA                                      TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA.  MANN.  SLOPE    HN    TERM.  SLOPE     HC      HN    ENTRY  ENTRY ENTRY  UPJUMP  DOWN   DEPTH   ENERGY ENERGY  ENERGY  JUMP  JUMP
L/S   M.    COEFF  (SIN)    M.    ENERGY (SIN)     M.      M.    DEPTH  ENERGY F.N   DEPTH   DEPTH  CHANGE  UPJUMP DOWN    CHANGE  F.N.  POS.
                                  M.                              M.     M.     N.     M.      M.     M.       M.     M.      M.     N.    M.

8.0 0.15 0.015 0.8660 0.016 0.611 0.0250 0.066 0.052                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

6.0 0.15 0.015 0.8660 0.013 0.498 0.0250 0.055 0.042                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.8660 0.010 0.369 0.0250 0.042 0.032                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.8660 0.007 0.220 0.0250 0.026 0.020                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.8660 0.004 0.130 0.0250 0.017 0.013                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.8660 0.016 0.611 0.0125 0.066 0.067 0.015  0.6327.865 0.066 0.067  0.000  0.099  0.049 -0.003 9.670 0.433

6.0 0.15 0.015 0.8660 0.013 0.498 0.0125 0.055 0.054                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

4.0 0.15 0.015 0.8660 0.010 0.369 0.0125 0.042 0.040                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

2.0 0.15 0.015 0.8660 0.007 0.220 0.0125 0.026 0.025                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

1.0 0.15 0.015 0.8660 0.004 0.130 0.0125 0.017 0.016                    JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

8.0 0.15 0.015 0.8660 0.016 0.611 0.0100 0.066 0.072 0.015  0.6327.865 0.061 0.072  0.012  0.100  0.100 -0.000 9.746 3.573

6.0 0.15 0.015 0.8660 0.013 0.498 0.0100 0.055 0.058 0.013  0.5118.867 0.051 0.058  0.007  0.082  0.082 -0.000 6.620 3.157

4.0 0.15 0.015 0.8660 0.010 0.369 0.0100 0.042 0.044 0.010  0.3810.840 0.040 0.044  0.004  0.063  0.063 -0.000 3.846 2.676

2.0 0.15 0.015 0.8660 0.007 0.220 0.0100 0.026 0.027 0.006  0.23 4.186 0.026 0.027  0.002  0.039  0.039 -0.000 1.525 1.527

1.0 0.15 0.015 0.8660 0.004 0.130 0.0100 0.017 0.017 0.004  0.13 1.609 0.016 0.017  0.001  0.025  0.025 -0.000 0.605 0.330

8.0 0.15 0.015 0.8660 0.016 0.611 0.0050 0.066 0.094 0.015  0.6327.865 0.045 0.094  0.049  0.118  0.110 -0.00711.037 2.423

6.0 0.15 0.015 0.8660 0.013 0.498 0.0050 0.055 0.076 0.013  0.5118.867 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 2.335

4.0 0.15 0.015 0.8660 0.010 0.369 0.0050 0.042 0.056 0.010  0.3810.840 0.030 0.056  0.026  0.070  0.068 -0.003 4.212 1.563



2.0 0.15 0.015 0.8660 0.007 0.220 0.0050 0.026 0.034 0.006  0.23 4.186 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 1.338

1.0 0.15 0.015 0.8660 0.004 0.130 0.0050 0.017 0.022 0.004  0.13 1.609 0.012 0.022  0.004  0.027  0.026 -0.001 0.652 0.577
```

```
 COMMON DATA  APPROACH PIPE DATA                    TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F.N. DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                         M.    M.     N.   M.     M.    M.      M.     M.     M.     N.    M.

 8.0 0.15 0.015 0.9659 0.015 0.654 0.0250 0.066 0.052              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 6.0 0.15 0.015 0.9659 0.013 0.532 0.0250 0.055 0.042              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.9659 0.010 0.395 0.0250 0.042 0.032              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.9659 0.006 0.235 0.0250 0.026 0.020              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.9659 0.004 0.138 0.0250 0.017 0.013              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.9659 0.015 0.654 0.0125 0.066 0.067 0.015  0.6728.826 0.066 0.067  0.000  0.099  0.099 -0.003 9.670 4.073
 6.0 0.15 0.015 0.9659 0.013 0.532 0.0125 0.055 0.054              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 4.0 0.15 0.015 0.9659 0.010 0.395 0.0125 0.042 0.040              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 2.0 0.15 0.015 0.9659 0.006 0.235 0.0125 0.026 0.025              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 1.0 0.15 0.015 0.9659 0.004 0.138 0.0125 0.017 0.016              JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.
 8.0 0.15 0.015 0.9659 0.015 0.654 0.0100 0.066 0.072 0.015  0.6728.826 0.061 0.072  0.012  0.100  0.100 -0.000 9.746 3.725
 6.0 0.15 0.015 0.9659 0.013 0.532 0.0100 0.055 0.058 0.012  0.5419.492 0.051 0.058  0.007  0.082  0.082 -0.000 6.620 3.133
 4.0 0.15 0.015 0.9659 0.010 0.395 0.0100 0.042 0.044 0.010  0.4011.207 0.040 0.044  0.004  0.063  0.063 -0.000 3.846 2.531
 2.0 0.15 0.015 0.9659 0.006 0.235 0.0100 0.026 0.027 0.006  0.24 4.323 0.026 0.027  0.002  0.039  0.039 -0.000 1.525 1.563
 1.0 0.15 0.015 0.9659 0.004 0.138 0.0100 0.017 0.017 0.004  0.14 1.654 0.016 0.017  0.001  0.025  0.025 -0.000 0.605 0.873
 8.0 0.15 0.015 0.9659 0.015 0.654 0.0050 0.066 0.094 0.015  0.6728.826 0.045 0.094  0.049  0.118  0.110 -0.00711.037 2.456
 6.0 0.15 0.015 0.9659 0.013 0.532 0.0050 0.055 0.076 0.012  0.5419.492 0.038 0.076  0.037  0.094  0.090 -0.005 7.374 2.121
 4.0 0.15 0.015 0.9659 0.010 0.395 0.0050 0.042 0.056 0.010  0.4011.207 0.030 0.056  0.026  0.070  0.068 -0.003 4.212 1.557
 2.0 0.15 0.015 0.9659 0.006 0.235 0.0050 0.026 0.034 0.005  0.24 4.323 0.020 0.034  0.015  0.043  0.042 -0.001 1.645 1.323
 1.0 0.15 0.015 0.9659 0.004 0.138 0.0050 0.017 0.022 0.004  0.14 1.654 0.012 0.022  0.009  0.027  0.026 -0.001 0.652 0.535
```

```
COMMON DATA  APPROACH PIPE DATA                       TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE   HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP JUMP   DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)   M.  ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                          M.    M.    N.    M.     M.     M.      M.     M.     M.    N.    M.

 8.0 0.15 0.015 1.0000 0.015 0.668 0.0250 0.066 0.052                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 6.0 0.15 0.015 1.0000 0.012 0.544 0.0250 0.055 0.042                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 1.0000 0.010 0.404 0.0250 0.042 0.032                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 1.0000 0.006 0.240 0.0250 0.026 0.020                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 1.0000 0.004 0.141 0.0250 0.017 0.013                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 1.0000 0.015 0.668 0.0125 0.066 0.067 0.015  0.6829.128 0.066 0.067  0.000   0.099  0.099 -0.003 9.670 4.492

 6.0 0.15 0.015 1.0000 0.012 0.544 0.0125 0.055 0.054                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 4.0 0.15 0.015 1.0000 0.010 0.404 0.0125 0.042 0.040                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 2.0 0.15 0.015 1.0000 0.006 0.240 0.0125 0.026 0.025                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 1.0 0.15 0.015 1.0000 0.004 0.141 0.0125 0.017 0.016                  JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.

 8.0 0.15 0.015 1.0000 0.015 0.668 0.0100 0.066 0.072 0.015  0.6829.128 0.061 0.072  0.012   0.100  0.100 -0.003 9.746 3.739

 6.0 0.15 0.015 1.0000 0.012 0.544 0.0100 0.055 0.058 0.012  0.5619.710 0.051 0.058  0.007   0.082  0.082 -0.003 6.620 3.236

 4.0 0.15 0.015 1.0000 0.010 0.404 0.0100 0.042 0.044 0.009  0.4111.329 0.040 0.044  0.004   0.063  0.063 -0.003 3.646 2.513

 2.0 0.15 0.015 1.0000 0.006 0.240 0.0100 0.026 0.027 0.006  0.25 4.365 0.025 0.027  0.002   0.039  0.039 -0.000 1.525 1.547

 1.0 0.15 0.015 1.0000 0.004 0.141 0.0100 0.017 0.017 0.004  0.15 1.677 0.016 0.017  0.001   0.025  0.025 -0.003 0.605 0.333

 8.0 0.15 0.015 1.0000 0.015 0.668 0.0050 0.066 0.094 0.015  0.6829.128 0.045 0.094  0.049   0.118  0.110 -0.00711.637 2.932

 6.0 0.15 0.015 1.0000 0.012 0.544 0.0050 0.055 0.076 0.012  0.5619.710 0.038 0.076  0.037   0.094  0.090 -0.005 7.374 2.133

 4.0 0.15 0.015 1.0000 0.010 0.404 0.0050 0.042 0.056 0.009  0.4111.329 0.030 0.055  0.026   0.070  0.068 -0.003 4.212 1.575

 2.0 0.15 0.015 1.0000 0.006 0.240 0.0050 0.026 0.034 0.006  0.25 4.365 0.020 0.034  0.015   0.043  0.042 -0.001 1.645 1.324

 1.0 0.15 0.015 1.0000 0.004 0.141 0.0050 0.017 0.022 0.004  0.15 1.677 0.012 0.022  0.009   0.027  0.026 -0.001 0.652 0.533
```

APPENDIX 7

JUMP FORMATION INDICATOR TAKES FOR CONSTANT MANNING COEFFICIENT OF 0.015 FOR BOTH CIRCULAR AND RECTANGULAR CROSS SECTION CHANNELS

TABULATED NORMAL FLOW DEPTHS FOR A CIRCULAR CROSS SECTION CHANNEL OF DIAMETER 0.1500 M. AND MANNING COEFF. 0.0150

FLOW RATE =	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000 L/S.	PIPE DIA. OR WIDTH M.
				NORMAL DEPTH M.					
PIPE SLOPE (SIN)									
0.0017	0.0435	0.0624	0.0795	0.0956	0.1132	0.1499	0.1499	0.1499	0.1500
0.0025	0.0394	0.0567	0.0709	0.0843	0.0976	0.1121	0.1334	0.1499	0.1500
0.0033	0.0369	0.0526	0.0656	0.0774	0.0888	0.1006	0.1136	0.1321	0.1500
0.0050	0.0332	0.0471	0.0585	0.0686	0.0781	0.0874	0.0969	0.1069	0.1500
0.0066	0.0309	0.0438	0.0542	0.0635	0.0720	0.0802	0.0883	0.0965	0.1500
0.0100	0.0279	0.0394	0.0486	0.0567	0.0640	0.0709	0.0776	0.0843	0.1500
0.0125	0.0264	0.0373	0.0459	0.0534	0.0602	0.0665	0.0727	0.0786	0.1500
0.0250	0.0223	0.0314	0.0384	0.0445	0.0500	0.0550	0.0593	0.0644	0.1500
				******					
0.0349	0.0206	0.0289	0.0353	0.0408	0.0458	0.0504	0.0547	0.0588	0.1500
0.0698	0.0174	0.0244	0.0297	0.0343	0.0383	0.0421	0.0456	0.0488	0.1500
0.1045	0.0158	0.0221	0.0269	0.0310	0.0347	0.0380	0.0411	0.0440	0.1500
0.1736	0.0140	0.0195	0.0238	0.0274	0.0306	0.0335	0.0361	0.0386	0.1500
0.3402	0.0120	0.0166	0.0202	0.0232	0.0259	0.0283	0.0306	0.0326	0.1500
0.5000	0.0107	0.0152	0.0184	0.0211	0.0236	0.0258	0.0278	0.0297	0.1500
0.7070	0.0101	0.0140	0.0170	0.0195	0.0217	0.0237	0.0255	0.0273	0.1500
0.8660	0.0096	0.0133	0.0162	0.0185	0.0206	0.0225	0.0243	0.0259	0.1500
0.9659	0.0094	0.0130	0.0157	0.0181	0.0201	0.0220	0.0237	0.0253	0.1500
1.0000	0.0093	0.0129	0.0156	0.0179	0.0199	0.0218	0.0235	0.0250	0.1500
CRITICAL DEPTH M.	0.0280	0.0400	0.0493	0.0572	0.0643	0.0707	0.0767	0.0821	

```
TABULATED VALUES OF F+M AT NORMAL DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER     0.1500 M. AND MANNING COEFF.     0.015


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.     PIPE DIA. OR
                                                                                                    WIDTH M.

                                   F+M VALUE AT NORMAL DEPTH, N.
PIPE SLOPE
  (SIN)
   0.0017       0.9844    2.3856    4.1076    6.1988    8.8620   15.0137   15.7493   16.5982            0.1500
   0.0025       0.8589    2.0697    3.5129    5.1930    7.1472    9.5115   13.1413   16.5982            0.1500
   0.0033       0.7951    1.9059    3.2200    4.7119    6.3926    8.3087   10.5882   13.8604            0.1500
   0.0050       0.7304    1.7497    2.9383    4.2653    5.7245    7.3133    9.0654   11.0078            0.1500
   0.0066       0.7059    1.6923    2.8366    4.1065    5.4857    6.9729    8.5674   10.2835            0.1500
   0.0100       0.6937    1.6678    2.7930    4.0332    5.3707    6.7951    8.2992    9.8852            0.1500
   0.0125       0.6980    1.6806    2.8159    4.0647    5.4080    6.8343    8.3347    9.9054            0.1500
   0.0250       0.7546    1.8266    3.0707    4.4351    5.8970    7.4453    9.0672   10.7473            0.1500

                                             ******

   0.0349       0.8036    1.9541    3.2853    4.7502    6.3174    7.9801    9.7118   11.5125            0.1500
   0.0698       0.9512    2.3248    3.9208    5.6741    7.5635    9.5548   11.6299   13.8159            0.1500
   0.1045       1.0657    2.6122    4.4071    6.3860    8.5183   10.7741   13.1394   15.5854            0.1500
   0.1736       1.2452    3.0598    5.1666    7.4932    9.9927   12.6432   15.4262   18.3234            0.1500
   0.3402       1.5474    3.8077    6.4485    9.3483   12.4756   15.7973   19.2824   22.9158            0.1500
   0.5000       1.7556    4.3266    7.3248   10.6593   14.2320   18.0141   21.9978   26.1227            0.1500
   0.7070       1.9737    4.8691    8.2446   11.9879   15.9899   20.2867   24.7411   29.4151            0.1500
   0.8660       2.1164    5.2191    8.8396   12.8413   17.1735   21.7516   26.5538   31.5457            0.1500
   0.9659       2.1947    5.4112    9.1817   13.3386   17.6022   22.5836   27.5516   32.7849            0.1500
   1.0000       2.2198    5.4780    9.2905   13.4955   18.0367   22.8553   27.9198   33.1944            0.1500
```

```
TABULATED NORMAL FLOW DEPTHS FOR A CIRCULAR CROSS SECTION CHANNEL OF DIAMETER     0.1000 M. AND MANNING COEFF.     0.0150


FLOW RATE =      1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.     PIPE DIA. OR
                                                                                                     WIDTH M.
                                                  NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
   0.0017        0.0524    0.0999    0.0999    0.0999    0.0999    0.0999    0.0999    0.0999               0.1000
   0.0025        0.0468    0.0737    0.0999    0.0999    0.0999    0.0999    0.0999    0.0999               0.1000
   0.0033        0.0433    0.0663    0.0999    0.0999    0.0999    0.0999    0.0999    0.0999               0.1000
   0.0050        0.0396    0.0577    0.0776    0.0999    0.0999    0.0999    0.0999    0.0999               0.1000
   0.0066        0.0358    0.0524    0.0692    0.0999    0.0999    0.0999    0.0999    0.0999               0.1000
   0.0100        0.0321    0.0468    0.0599    0.0737    0.0999    0.0999    0.0999    0.0999               0.1000
   0.0125        0.0303    0.0439    0.0557    0.0675    0.0818    0.0999    0.0999    0.0999               0.1000
   0.0250        0.0254    0.0364    0.0454    0.0538    0.0620    0.0707    0.0809    0.0999               0.1000

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   0.0349        0.0234    0.0333    0.0414    0.0487    0.0557    0.0626    0.0700    0.0783               0.1000
   0.0698        0.0196    0.0278    0.0344    0.0401    0.0454    0.0504    0.0553    0.0602               0.1000
   0.1045        0.0178    0.0251    0.0309    0.0359    0.0406    0.0448    0.0490    0.0531               0.1000
   0.1736        0.0157    0.0221    0.0271    0.0314    0.0353    0.0390    0.0424    0.0457               0.1000
   0.3402        0.0134    0.0187    0.0229    0.0264    0.0297    0.0326    0.0353    0.0380               0.1000
   0.5000        0.0122    0.0170    0.0208    0.0240    0.0269    0.0295    0.0320    0.0343               0.1000
   0.7070        0.0112    0.0157    0.0191    0.0220    0.0246    0.0270    0.0292    0.0313               0.1000
   0.8660        0.0107    0.0149    0.0182    0.0209    0.0234    0.0256    0.0277    0.0297               0.1000
   0.9659        0.0104    0.0145    0.0177    0.0204    0.0228    0.0249    0.0270    0.0289               0.1000
   1.0000        0.0103    0.0144    0.0175    0.0202    0.0225    0.0247    0.0267    0.0286               0.1000

CRITICAL         0.0315    0.0451    0.0557    0.0648    0.0725    0.0792    0.0848    0.0892
DEPTH M.
```

TABULATED VALUES OF F+M AT NORMAL DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER 0.1000 M. AND MANNING COEFF. 0.015

FLOW RATE =	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000 L/S.	PIPE DIA. OR WIDTH M.
				F+M VALUE AT NORMAL DEPTH, M.					
PIPE SLOPE (SIN)									
0.0017	1.1524	4.3542	4.9908	5.8821	7.0281	8.4287	10.0840	11.9940	0.1000
0.0025	0.9765	2.6443	4.9908	5.8821	7.0281	8.4287	10.0840	11.9940	0.1000
0.0033	0.8879	2.2964	4.9908	5.8821	7.0281	8.4287	10.0840	11.9940	0.1000
0.0050	0.7993	1.9942	3.6201	5.8821	7.0281	8.4287	10.0840	11.9940	0.1000
0.0066	0.7647	1.8813	3.2872	5.8821	7.0281	8.4287	10.0840	11.9940	0.1000
0.0100	0.7429	1.8081	3.0794	4.5785	7.0281	8.4287	10.0840	11.9940	0.1000
0.0125	0.7441	1.6060	3.0544	4.4767	6.1556	8.4287	10.0840	11.9940	0.1000
0.0250	0.7980	1.9333	3.2447	4.6871	6.2380	7.8872	9.6582	11.9940	0.1000

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0.0349	0.8479	2.0586	3.4539	4.9816	6.6116	8.3339	10.1267	11.9907	0.1000
0.0698	1.0033	2.4436	4.1026	5.9253	7.8626	9.8981	12.0249	14.2135	0.1000
0.1045	1.1254	2.7435	4.6206	6.6778	8.8645	11.1807	13.5908	16.0513	0.1000
0.1736	1.3126	3.2151	5.4151	7.8421	10.4335	13.1515	16.0075	18.9462	0.1000
0.3402	1.6337	4.0108	6.7653	9.8076	13.0490	16.4949	20.1069	23.8240	0.1000
0.5000	1.8574	4.5672	7.7140	11.1868	14.8881	18.8540	22.9368	27.2368	0.1000
0.7070	2.0902	5.1354	8.6901	12.5945	16.8191	21.2520	25.3695	30.7542	0.1000
0.8660	2.2383	5.5082	9.3199	13.5039	18.0339	22.8261	27.8166	32.9663	0.1000
0.9659	2.3254	5.7202	9.5667	14.0281	18.7102	23.6962	28.8592	34.2663	0.1000
1.0000	2.3531	5.7894	9.7810	14.1951	18.9650	23.9560	29.2229	34.7480	0.1000

```
TABULATED NORMAL FLOW DEPTHS FOR A CIRCULAR CROSS SECTION CHANNEL OF DIAMETER     0.0750 M. AND MANNING COEFF.     0.0150


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.      PIPE DIA. OR
                                                                                                      WIDTH M.

                                              NORMAL DEPTH M.
PIPE SLOPE
  (S:M)
   0.0017       0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0025       0.0590    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0033       0.0525    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0050       0.0454    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0066       0.0415    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0100       0.0367    0.0590    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0125       0.0344    0.0536    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0250       0.0284    0.0422    0.0563    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750


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   0.0349       0.0259    0.0381    0.0495    0.0637    0.0749    0.0749    0.0749    0.0749              0.0750
   0.0698       0.0217    0.0313    0.0395    0.0475    0.0561    0.0749    0.0749    0.0749              0.0750
   0.1045       0.0195    0.0280    0.0351    0.0416    0.0482    0.0552    0.0646    0.0749              0.0750
   0.1736       0.0172    0.0245    0.0305    0.0358    0.0408    0.0459    0.0511    0.0569              0.0750
   0.3402       0.0146    0.0206    0.0254    0.0296    0.0336    0.0372    0.0408    0.0444              0.0750
   0.5000       0.0132    0.0187    0.0230    0.0267    0.0302    0.0333    0.0364    0.0394              0.0750
   0.7070       0.0122    0.0171    0.0210    0.0244    0.0274    0.0303    0.0330    0.0356              0.0750
   0.8660       0.0116    0.0163    0.0200    0.0231    0.0260    0.0287    0.0312    0.0336              0.0750
   0.9659       0.0113    0.0158    0.0194    0.0225    0.0253    0.0279    0.0303    0.0326              0.0750
   1.0000       0.0112    0.0157    0.0192    0.0223    0.0250    0.0276    0.0300    0.0323              0.0750


CRITICAL        0.0343    0.0493    0.0602    0.0675    0.0714    0.0732    0.0740    0.0745
DEPTH M.
```

TABULATED VALUES OF F+M AT NORMAL DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER 0.0750 M. AND MANNING COEFF. 0.015

F+M VALUE AT NORMAL DEPTH, N.

FLOW RATE =	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000 L/S.	PIPE DIA. OR WIDTH M.
PIPE SLOPE (SIN)									
0.0017	1.8484	2.5275	3.6593	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750
0.0025	1.2441	2.5275	3.6593	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750
0.0033	1.0537	2.5275	3.6593	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750
0.0050	0.8959	2.5275	3.6593	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750
0.0066	0.8359	2.5275	3.6593	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750
0.0100	0.7929	2.0488	3.6593	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750
0.0125	0.7871	1.9713	3.6593	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750
0.0250	0.8308	2.0162	3.4093	5.2439	7.2812	9.7712	12.7140	16.1094	0.0750

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0.0349	0.8805	2.1314	3.5674	5.1546	7.2812	9.7712	12.7140	16.1094	0.0750
0.0698	1.0383	2.5161	4.2028	6.0213	7.9212	9.7712	12.7140	16.1094	0.0750
0.1045	1.1647	2.8276	4.7304	6.7920	8.9567	11.1711	13.2922	16.1094	0.0750
0.1736	1.3606	3.3120	5.5568	7.9967	10.5875	13.2590	15.9919	18.7031	0.0750
0.3402	1.6932	4.1399	6.9687	10.0487	13.3254	16.7799	20.3471	23.9933	0.0750
0.5000	1.9250	4.7151	7.9481	11.4903	15.2496	19.2302	23.3491	27.5645	0.0750
0.7070	2.1709	5.3153	8.9725	12.9768	17.2390	21.7318	26.4124	31.2549	0.0750
0.8660	2.3273	5.7003	9.5076	13.9265	18.5060	23.3802	28.4258	33.6524	0.0750
0.9659	2.4134	5.9220	9.9834	14.4520	19.2647	24.2779	29.5510	35.0188	0.0750
1.0000	2.4414	5.9995	10.1146	14.6464	19.4924	24.5776	29.9298	35.4296	0.0750

```
TABULATED NORMAL FLOW DEPTHS FOR A RECTANGULAR CHANNEL OF WIDTH     0.1500 M. AND MANNING COEFF.    0.0150


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.     PIPE DIA. OR
                                                                                                  WIDTH M.

                                             NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
   0.0017       0.0310    0.0501    0.0673    0.0836    0.0992    0.1145    0.1294    0.1442              0.1500
   0.0025       0.0272    0.0438    0.0585    0.0723    0.0855    0.0964    0.1110    0.1234              0.1500
   0.0033       0.0248    0.0397    0.0528    0.0652    0.0770    0.0884    0.0995    0.1105              0.1500
   0.0050       0.0216    0.0344    0.0456    0.0560    0.0660    0.0755    0.0849    0.0940              0.1500
   0.0066       0.0197    0.0313    0.0413    0.0507    0.0596    0.0681    0.0764    0.0844              0.1500
   0.0100       0.0172    0.0272    0.0358    0.0438    0.0512    0.0585    0.0654    0.0723              0.1500
   0.0125       0.0160    0.0252    0.0332    0.0405    0.0474    0.0539    0.0603    0.0665              0.1500
   0.0250       0.0128    0.0201    0.0262    0.0318    0.0371    0.0422    0.0470    0.0517              0.1500

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   0.0349       0.0115    0.0180    0.0235    0.0284    0.0331    0.0375    0.0418    0.0459              0.1500
   0.0698       0.0093    0.0144    0.0187    0.0226    0.0262    0.0296    0.0329    0.0360              0.1500
   0.1045       0.0082    0.0126    0.0164    0.0198    0.0229    0.0258    0.0287    0.0314              0.1500
   0.1736       0.0070    0.0108    0.0139    0.0168    0.0194    0.0218    0.0242    0.0265              0.1500
   0.3402       0.0057    0.0087    0.0112    0.0135    0.0156    0.0175    0.0194    0.0211              0.1500
   0.5000       0.0050    0.0077    0.0100    0.0119    0.0138    0.0155    0.0171    0.0187              0.1500
   0.7070       0.0045    0.0069    0.0089    0.0107    0.0123    0.0139    0.0153    0.0167              0.1500
   0.8660       0.0042    0.0065    0.0084    0.0100    0.0116    0.0130    0.0143    0.0156              0.1500
   0.9659       0.0041    0.0063    0.0081    0.0097    0.0112    0.0125    0.0138    0.0151              0.1500
   1.0000       0.0041    0.0062    0.0080    0.0096    0.0111    0.0124    0.0137    0.0149              0.1500

CRITICAL        0.0165    0.0263    0.0344    0.0417    0.0484    0.0546    0.0605    0.0662
DEPTH M.
```

TABULATED VALUES OF F*M AT NORMAL DEPTHS IN A RECTANGULAR CHANNEL OF WIDTH 0.1500 M. AND MANNING COEFF. 0.0150

FLOW RATE =	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000 L/S.	PIPE DIA. OR WIDTH M.
				F*M VALUE AT NORMAL DEPTH, M.					
PIPE SLOPE (SIN)									
0.0017	0.9207	2.3812	4.2279	6.4147	8.9259	11.7385	14.8474	18.2604	0.1500
0.0025	0.7892	2.0184	3.5425	5.3173	7.3251	9.5587	12.0029	14.6632	0.1500
0.0033	0.7207	1.8297	3.1900	4.7653	6.5248	8.4648	10.5713	12.8478	0.1500
0.0050	0.6517	1.6450	2.8454	4.2118	5.7275	7.3736	9.1500	11.0374	0.1500
0.0066	0.6238	1.5720	2.7089	3.9958	5.4092	6.9353	8.5698	10.2994	0.1500
0.0100	0.6053	1.5247	2.6189	3.8465	5.1843	6.6202	8.1427	9.7462	0.1500
0.0125	0.6050	1.5254	2.6184	3.8407	5.1694	6.5901	8.0926	9.6698	0.1500
0.0250	0.6408	1.6258	2.7932	4.0959	5.5052	7.0010	8.5768	10.2216	0.1500

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0.0349	0.6761	1.7204	2.9628	4.3460	5.8427	7.4304	9.1025	10.8475	0.1500
0.0698	0.7821	2.0063	3.4666	5.0996	6.8659	8.7509	10.7337	12.8007	0.1500
0.1045	0.8658	2.2267	3.9570	5.6861	7.6620	9.7804	12.0038	14.3267	0.1500
0.1736	0.9920	2.5640	4.4514	6.5699	8.8718	11.3378	13.9357	16.6408	0.1500
0.3402	1.2009	3.1170	5.4340	8.0330	10.8806	13.9151	17.1231	20.5037	0.1500
0.5000	1.3438	3.4970	6.1019	9.0329	12.2514	15.6786	19.3262	23.1233	0.1500
0.7070	1.4898	3.8806	6.7769	10.0508	13.6267	17.4673	21.5503	25.8244	0.1500
0.8660	1.5835	4.1250	7.2102	10.6948	14.5120	18.6237	22.9502	27.5126	0.1500
0.9659	1.6351	4.2658	7.4576	11.0709	15.0256	19.2641	23.7548	28.4972	0.1500
1.0000	1.6531	4.3088	7.5328	11.1954	15.1722	19.4879	24.0361	28.8070	0.1500

```
TABULATED NORMAL FLOW DEPTHS FOR A RECTANGULAR CHANNEL OF WIDTH     0.0100 M. AND MANNING COEFF.    0.0150


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.    PIPE DIA. OR
                                                                                                     WIDTH M.

                                                NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
    0.0017      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0025      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0033      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0050      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0066      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0100      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0125      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0250      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100

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    0.0349      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.0698      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.1045      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.1736      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.3402      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.5000      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.7070      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.8660      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    0.9659      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100
    1.0000      0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100              0.0100

CRITICAL        0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100    0.0100
DEPTH M.
```

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TABULATED VALUES OF F*M AT NORMAL DEPTHS IN A RECTANGULAR CHANNEL OF WIDTH     0.0100 M. AND MANNING COEFF.     0.0150


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.      PIPE DIA. OR
                                                                                                       WIDTH M.

                                          F*M VALUE AT NORMAL DEPTH, M.
PIPE SLOPE
  (SIN)
    0.0017      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0025      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0033      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0050      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0066      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0100      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0125      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0250      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100

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    0.0349      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.0698      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.1045      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.1736      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.3402      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.5000      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.7070      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.8660      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    0.9659      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
    1.0000      10.0147   40.0440   90.0928  160.1610  250.2491  360.3562  490.4836  640.6299             0.0100
```

```
TABULATED NORMAL FLOW DEPTHS FOR A RECTANGULAR CHANNEL OF WIDTH      0.0750 M. AND MANNING COEFF.    0.0150


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.      PIPE DIA. OR
                                                                                                       WIDTH M.

                                                  NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
    0.0017      0.0599    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
    0.0025      0.0514    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
    0.0033      0.0462    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
    0.0050      0.0394    0.0677    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
    0.0066      0.0355    0.0605    0.0749    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
    0.0100      0.0305    0.0514    0.0710    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
    0.0125      0.0281    0.0471    0.0649    0.0749    0.0749    0.0749    0.0749    0.0749              0.0750
    0.0250      0.0219    0.0362    0.0493    0.0619    0.0742    0.0749    0.0749    0.0749              0.0750

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    0.0349      0.0195    0.0320    0.0434    0.0542    0.0648    0.0749    0.0749    0.0749              0.0750
    0.0698      0.0154    0.0249    0.0335    0.0415    0.0493    0.0568    0.0642    0.0715              0.0750
    0.1045      0.0134    0.0216    0.0288    0.0357    0.0422    0.0485    0.0547    0.0608              0.0750
    0.1736      0.0113    0.0181    0.0240    0.0296    0.0348    0.0400    0.0449    0.0496              0.0750
    0.3402      0.0091    0.0144    0.0190    0.0232    0.0272    0.0311    0.0348    0.0385              0.0750
    0.5000      0.0080    0.0126    0.0166    0.0203    0.0237    0.0270    0.0302    0.0333              0.0750
    0.7070      0.0072    0.0113    0.0148    0.0180    0.0210    0.0239    0.0267    0.0294              0.0750
    0.8660      0.0067    0.0105    0.0138    0.0168    0.0196    0.0222    0.0248    0.0273              0.0750
    0.9659      0.0065    0.0102    0.0133    0.0162    0.0188    0.0214    0.0239    0.0262              0.0750
    1.0000      0.0064    0.0101    0.0132    0.0160    0.0186    0.0211    0.0236    0.0259              0.0750


CRITICAL        0.0263    0.0417    0.0546    0.0662    0.0749    0.0749    0.0749    0.0749
DEPTH M.
```

```
TABULATED VALUES OF F*M AT NORMAL DEPTHS IN A RECTANGULAR CHANNEL OF WIDTH     0.0750 M. AND MANNING COEFF.     0.0150


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.      PIPE DIA. OR
                                                                                                     WIDTH M.

                                       F*M VALUE AT NORMAL DEPTH. M.
PIPE SLOPE
  (SIN)
    0.0017      1.5415    2.7771    3.6668    4.9125    6.5140    8.4715   10.7849   13.4542              0.0750
    0.0025      1.2306    2.7771    3.6668    4.9125    6.5140    8.4715   10.7849   13.4542              0.0750
    0.0033      1.0732    2.7771    3.6668    4.9125    6.5140    8.4715   10.7849   13.4542              0.0750
    0.0050      0.9088    2.4743    3.6668    4.9125    6.5140    8.4715   10.7849   13.4542              0.0750
    0.0066      0.8393    2.2291    3.5668    4.9125    6.5140    8.4715   10.7849   13.4542              0.0750
    0.0100      0.7790    2.0092    3.5448    4.9125    6.5140    8.4715   10.7849   13.4542              0.0750
    0.0125      0.7649    1.9488    3.3976    4.9125    6.5140    8.4715   10.7849   13.4542              0.0750
    0.0250      0.7851    1.9549    3.3278    4.8557    6.5178    8.4715   10.7849   13.4542              0.0750

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    0.0349      0.8236    2.0427    3.4580    5.0155    6.6893    8.4715   10.7849   13.4542              0.0750
    0.0698      0.9543    2.3686    3.9988    5.7749    7.6600    9.6376   11.0932   13.8130              0.0750
    0.1045      1.0591    2.6419    4.4670    6.4516    8.5617   10.7564   13.0491   15.3898              0.0750
    0.1736      1.2228    3.0671    5.2040    7.5358   10.0129   12.6012   15.2826   18.0574              0.0750
    0.3402      1.4977    3.7842    6.4524    9.3797   12.5151   15.7853   19.1764   22.7159              0.0750
    0.5000      1.6852    4.2771    7.3232   10.6758   14.2643   18.0175   21.9478   26.0012              0.0750
    0.7070      1.8754    4.7790    8.1963   11.9774   16.0336   20.2977   24.7510   29.3541              0.0750
    0.8660      1.9994    5.1020    8.7676   12.8159   17.1703   21.7577   26.5531   31.5306              0.0750
    0.9659      2.0682    5.2815    9.0859   13.2981   17.8220   22.5932   27.5929   32.7748              0.0750
    1.0000      2.0912    5.3379    9.1849   13.4473   18.0277   22.8610   27.9282   33.1822              0.0750
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APPENDIX 8

JUMP FORMATION INDICATOR TABLES FOR 0.15 m PIPE DIAMETER FOR A RANGE OF MANNING COEFFICIENTS FROM 0.009 TO 0.018

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TABULATED NORMAL FLOW DEPTHS FOR A CIRCULAR CROSS SECTION CHANNEL OF DIAMETER     0.1500 M. AND MANNING COEFF.     0.0180


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.      PIPE DIA. OR
                                                                                                    WIDTH M.

                                                 NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
    0.0017      0.0479    0.0697    0.0890    0.1094    0.1499    0.1499    0.1499    0.1499              0.1500
    0.0025      0.0433    0.0625    0.0790    0.0948    0.1121    0.1499    0.1499    0.1499              0.1500
    0.0033      0.0403    0.0580    0.0728    0.0866    0.1006    0.1165    0.1499    0.1499              0.1500
    0.0050      0.0363    0.0519    0.0646    0.0762    0.0874    0.0988    0.1113    0.1271              0.1500
    0.0066      0.0339    0.0482    0.0599    0.0703    0.0802    0.0899    0.0998    0.1107              0.1500
    0.0100      0.0306    0.0433    0.0535    0.0625    0.0709    0.0790    0.0868    0.0948              0.1500
    0.0125      0.0289    0.0409    0.0504    0.0589    0.0665    0.0739    0.0811    0.0881              0.1500
    0.0250      0.0244    0.0343    0.0422    0.0489    0.0550    0.0608    0.0662    0.0714              0.1500

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    0.0349      0.0225    0.0316    0.0387    0.0449    0.0504    0.0555    0.0603    0.0649              0.1500
    0.0698      0.0190    0.0266    0.0325    0.0376    0.0421    0.0463    0.0501    0.0538              0.1500
    0.1045      0.0173    0.0242    0.0295    0.0340    0.0380    0.0416    0.0451    0.0484              0.1500
    0.1736      0.0153    0.0213    0.0260    0.0299    0.0335    0.0367    0.0396    0.0424              0.1500
    0.3402      0.0130    0.0182    0.0221    0.0254    0.0283    0.0310    0.0335    0.0358              0.1500
    0.5000      0.0119    0.0166    0.0201    0.0231    0.0258    0.0282    0.0304    0.0325              0.1500
    0.7070      0.0110    0.0152    0.0185    0.0213    0.0237    0.0259    0.0279    0.0298              0.1500
    0.8660      0.0105    0.0145    0.0176    0.0202    0.0225    0.0246    0.0266    0.0284              0.1500
    0.9659      0.0102    0.0142    0.0172    0.0197    0.0220    0.0240    0.0259    0.0276              0.1500
    1.0000      0.0101    0.0140    0.0170    0.0195    0.0218    0.0238    0.0257    0.0274              0.1500

CRITICAL        0.0280    0.0400    0.0493    0.0572    0.0643    0.0707    0.0767    0.0821
DEPTH M.
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TABULATED VALUES OF F•M AT NORMAL DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER     0.1500 M. AND MANNING COEFF.     0.01


FLOW RATE =      1.0000     2.0000     3.0000     4.0000     5.0000     6.0000     7.0000     8.0000 L/S.       PIPE DIA. OR
                                                                                                              WIDTH M.

                                          F•M VALUE AT NORMAL DEPTH, M.
PIPE SLUPE
  (SIN)
    0.0017       1.1497     2.8170     4.9391     7.7482    14.3911    15.0137    15.7493    16.5982                0.1500
    0.0025       0.9769     2.3649     4.0733     6.1259     8.7352    15.0137    15.7493    16.5982                0.1500
    0.0033       0.6832     2.1300     3.6278     5.3807     7.4354    10.0377    15.7493    16.5982                0.1500
    0.0050       0.7846     1.8831     3.1749     4.6410     6.2839     8.1512    10.3355    13.1922                0.1500
    0.0066       0.7405     1.7754     2.9831     4.3346     5.8291     7.4668     9.2828    11.3472                0.1500
    0.0100       0.7030     1.6862     2.8247     4.0862     5.4579     6.9329     8.5061    10.2006                0.1500
    0.0125       0.6948     1.6687     2.7945     4.0379     5.3811     6.8165     8.3394     9.9506                0.1500
    0.0250       0.7166     1.7319     2.9036     4.1925     5.5738     7.0368     8.5717    10.1684                0.1500

                                                     ••••••


    0.0349       0.7504     1.8196     3.0543     4.4097     5.8673     7.4052     9.0159    10.6923                0.1500
    0.0698       0.8662     2.1107     3.5540     5.1371     6.8461     8.6404    10.5224    12.4816                0.1500
    0.1045       0.9603     2.3491     3.9598     5.7368     7.6462     9.6684    11.7778    13.9551                0.1500
    0.1736       1.1120     2.7306     4.6096     6.6785     8.9005    11.2529    13.7371    16.3096                0.1500
    0.3402       1.3736     3.3763     5.7122     8.2796    11.0505    13.9804    17.0665    20.2746                0.1500
    0.5000       1.5574     3.8312     6.4811     9.4097    12.5733    15.9100    19.4035    23.0919                0.1500
    0.7070       1.7472     4.3045     7.2840    10.5819    14.1396    17.9074    21.8374    25.9891                0.1500
    0.8660       1.8705     4.6032     7.8089    11.3462    15.1510    19.1890    23.4088    27.8297                0.1500
    0.9659       1.9382     4.7793     8.0946    11.7669    15.7253    19.8942    24.2992    28.9225                0.1500
    1.0000       1.9635     4.8419     8.1941    11.9240    15.9137    20.1543    24.5919    29.2493                0.1500
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TABULATED NORMAL FLOW DEPTHS FOR A CIRCULAR CROSS SECTION CHANNEL OF DIAMETER     0.1500 M. AND MANNING COEFF.     0.0150


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.     PIPE DIA. OR
                                                                                                       WIDTH M.

                                                NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
    0.0017      0.0435    0.0629    0.0795    0.0956    0.1132    0.1499    0.1499    0.1499              0.1500
    0.0025      0.0394    0.0567    0.0709    0.0843    0.0976    0.1121    0.1334    0.1499              0.1500
    0.0033      0.0368    0.0526    0.0656    0.0774    0.0888    0.1006    0.1136    0.1321              0.1500
    0.0050      0.0332    0.0471    0.0585    0.0686    0.0781    0.0874    0.0969    0.1069              0.1500
    0.0066      0.0309    0.0438    0.0542    0.0635    0.0720    0.0802    0.0883    0.0965              0.1500
    0.0100      0.0279    0.0394    0.0486    0.0567    0.0640    0.0709    0.0776    0.0843              0.1500
    0.0125      0.0264    0.0373    0.0459    0.0534    0.0602    0.0665    0.0727    0.0786              0.1500
    0.0250      0.0223    0.0314    0.0384    0.0445    0.0500    0.0550    0.0598    0.0644              0.1500


                                                       ******


    0.0349      0.0206    0.0269    0.0353    0.0408    0.0458    0.0504    0.0547    0.0588              0.1500
    0.0698      0.0174    0.0244    0.0297    0.0343    0.0383    0.0421    0.0456    0.0488              0.1500
    0.1045      0.0158    0.0221    0.0269    0.0310    0.0347    0.0380    0.0411    0.0440              0.1500
    0.1736      0.0140    0.0195    0.0238    0.0274    0.0306    0.0335    0.0361    0.0386              0.1500
    0.3402      0.0120    0.0166    0.0202    0.0232    0.0259    0.0283    0.0306    0.0326              0.1500
    0.5000      0.0109    0.0152    0.0184    0.0211    0.0236    0.0258    0.0278    0.0297              0.1500
    0.7070      0.0101    0.0140    0.0170    0.0195    0.0217    0.0237    0.0255    0.0273              0.1500
    0.8660      0.0096    0.0133    0.0162    0.0185    0.0206    0.0225    0.0243    0.0259              0.1500
    0.9659      0.0094    0.0130    0.0157    0.0181    0.0201    0.0220    0.0237    0.0253              0.1500
    1.0000      0.0093    0.0129    0.0156    0.0179    0.0199    0.0218    0.0235    0.0250              0.1500


CRITICAL        0.0280    0.0400    0.0493    0.0572    0.0643    0.0707    0.0767    0.0821
DEPTH M.
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```
TABULATED VALUES OF F*M AT NORMAL DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER     0.1500 M. AND MANNING COEFF.


FLOW RATE =      1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.     PIPE DIA. OR
                                                                                                      WIDTH M.

                                      F*M VALUE AT NORMAL DEPTH, M.
PIPE SLOPE
 (SIN)
   0.0017        0.9844    2.3856    4.1076    6.1988    8.8620   15.0137   15.7493   16.5982          0.1500
   0.0025        0.8549    2.0697    3.5129    5.1930    7.1472    9.5115   13.1413   16.5982          0.1500
   0.0033        0.7951    1.9059    3.2200    4.7119    6.3926    8.3087   10.5882   13.8604          0.1500
   0.0050        0.7304    1.7497    2.9383    4.2653    5.7245    7.3133    9.0654   11.0078          0.1500
   0.0066        0.7059    1.6923    2.8366    4.1065    5.4857    6.9729    8.5674   10.2835          0.1500
   0.0100        0.6937    1.6678    2.7930    4.0332    5.3707    6.7951    8.2992    9.8852          0.1500
   0.0125        0.6980    1.6808    2.8159    4.0647    5.4080    6.8343    8.3347    9.9054          0.1500
   0.0250        0.7546    1.8286    3.0707    4.4351    5.8970    7.4453    9.0672   10.7473          0.1500

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   0.0349        0.8036    1.9541    3.2853    4.7502    6.3174    7.9801    9.7118   11.5125          0.1500
   0.0698        0.9512    2.3248    3.9208    5.6741    7.5635    9.5548   11.6249   13.8159          0.1500
   0.1045        1.0657    2.6122    4.4071    6.3860    8.5183   10.7741   13.1394   15.5854          0.1500
   0.1736        1.2452    3.0598    5.1666    7.4932    9.9927   12.6432   15.4262   18.3234          0.1500
   0.3402        1.5474    3.8077    6.4485    9.3483   12.4756   15.7973   19.2824   22.9158          0.1500
   0.5000        1.7556    4.3266    7.3248   10.6593   14.2320   18.0141   21.9978   26.1227          0.1500
   0.7070        1.9737    4.8691    8.2446   11.9879   15.9849   20.2867   24.7411   29.4151          0.1500
   0.8660        2.1164    5.2191    8.8396   12.8413   17.1735   21.7516   26.5538   31.5457          0.1500
   0.9659        2.1947    5.4112    9.1817   13.3366   17.8022   22.5836   27.5516   32.7849          0.1500
   1.0000        2.2198    5.4780    9.2905   13.4955   18.0367   22.8553   27.9198   33.1944          0.1500
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TABULATED NORMAL FLOW DEPTHS FOR A CIRCULAR CROSS SECTION CHANNEL OF DIAMETER     0.1500 M. AND MANNING COEFF.     0.0120


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.     PIPE DIA. OR
                                                                                                   WIDTH M.

                                             NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
    0.0017      0.0389    0.0557    0.0697    0.0827    0.0956    0.1094    0.1272    0.1499              0.1500
    0.0025      0.0352    0.0503    0.0625    0.0736    0.0843    0.0948    0.1060    0.1190              0.1500
    0.0033      0.0329    0.0468    0.0580    0.0680    0.0774    0.0866    0.0959    0.1055              0.1500
    0.0050      0.0297    0.0420    0.0519    0.0605    0.0686    0.0762    0.0837    0.0912              0.1500
    0.0066      0.0277    0.0391    0.0482    0.0561    0.0635    0.0703    0.0770    0.0834              0.1500
    0.0100      0.0250    0.0352    0.0433    0.0503    0.0567    0.0625    0.0682    0.0736              0.1500
    0.0125      0.0237    0.0333    0.0409    0.0474    0.0534    0.0589    0.0641    0.0690              0.1500
    0.0250      0.0201    0.0281    0.0343    0.0397    0.0445    0.0489    0.0531    0.0570              0.1500

                                                  ******

    0.0349      0.0185    0.0259    0.0316    0.0365    0.0408    0.0449    0.0486    0.0521              0.1500
    0.0698      0.0157    0.0219    0.0266    0.0307    0.0343    0.0376    0.0406    0.0435              0.1500
    0.1045      0.0143    0.0198    0.0242    0.0278    0.0310    0.0340    0.0367    0.0392              0.1500
    0.1736      0.0126    0.0176    0.0213    0.0246    0.0274    0.0299    0.0323    0.0346              0.1500
    0.3402      0.0108    0.0150    0.0182    0.0209    0.0232    0.0254    0.0274    0.0292              0.1500
    0.5000      0.0098    0.0137    0.0166    0.0190    0.0211    0.0231    0.0249    0.0266              0.1500
    0.7070      0.0091    0.0126    0.0152    0.0175    0.0195    0.0213    0.0229    0.0244              0.1500
    0.8660      0.0086    0.0120    0.0145    0.0167    0.0185    0.0202    0.0218    0.0233              0.1500
    0.9659      0.0084    0.0117    0.0142    0.0162    0.0181    0.0197    0.0212    0.0227              0.1500
    1.0000      0.0084    0.0116    0.0140    0.0161    0.0179    0.0195    0.0211    0.0225              0.1500

CRITICAL        0.0280    0.0400    0.0493    0.0572    0.0643    0.0707    0.0767    0.0821
DEPTH M.
```

TABULATED VALUES OF F*M AT NORMAL DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER 0.1500 M. AND MANNING COEFF. 0.

FLOW RATE =	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000 L/S.	PIPE DIA. OR WIDTH M.
				F*M VALUE AT NORMAL DEPTH. M.					
PIPE SLOPE (SIN)									
0.0017	0.8436	2.0284	3.4389	5.0708	6.9560	9.1971	12.2726	16.5982	0.1500
0.0025	0.7639	1.8317	3.0021	4.4945	6.0728	7.8237	9.8111	12.2134	0.1500
0.0033	0.7270	1.7418	2.9232	4.2432	5.6901	7.2714	8.9948	10.8991	0.1500
0.0050	0.6977	1.6743	2.8048	4.0541	5.4081	6.8571	8.4016	10.0445	0.1500
0.0066	0.6937	1.6665	2.7943	4.0350	5.3720	6.7953	8.2976	9.8787	0.1500
0.0100	0.7091	1.7117	2.8684	4.1411	5.5059	6.9552	8.4740	10.0584	0.1500
0.0125	0.7270	1.7565	2.9496	4.2590	5.6619	7.1473	8.7044	10.3270	0.1500
0.0250	0.8233	2.0028	3.3716	4.8776	6.4855	8.1927	9.9704	11.8190	0.1500

◆◆◆◆◆◆

FLOW RATE =	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000 L/S.	PIPE DIA. OR WIDTH M.
0.0349	0.8911	2.1763	3.6658	5.3003	7.0616	8.9145	10.8599	12.8866	0.1500
0.0698	1.0796	2.6448	4.4672	6.4706	8.6300	10.9023	13.3123	15.7753	0.1500
0.1045	1.2200	3.0003	5.0639	7.3513	9.7936	12.3963	15.1334	17.9724	0.1500
0.1736	1.4366	3.5309	5.9807	8.6668	11.5725	14.6512	17.8740	21.2261	0.1500
0.3402	1.7939	4.4169	7.4871	10.8707	14.5161	18.3784	22.4505	26.6696	0.1500
0.5000	2.0428	5.0367	8.5329	12.3845	16.5833	20.9727	25.5187	30.4470	0.1500
0.7070	2.3000	5.6754	9.5141	13.9651	18.6726	23.6475	28.8796	34.3322	0.1500
0.8660	2.4550	6.0827	10.3053	14.9715	20.0126	25.3859	30.9843	36.8267	0.1500
0.9659	2.5595	6.3058	10.5941	15.5614	20.7930	26.3412	32.2200	38.2854	0.1500
1.0000	2.5842	6.3932	10.8363	15.7412	21.0390	26.6977	32.5425	38.7339	0.1500

```
TABULATED NORMAL FLOW DEPTHS FOR A CIRCULAR CROSS SECTION CHANNEL OF DIAMETER     0.1500 M. AND MANNING COEFF.     0.0090


FLOW RATE =      1.0000     2.0000     3.0000     4.0000     5.0000     6.0000     7.0000     8.0000 L/S.      PIPE DIA. OR
                                                                                                            WIDTH M.

                                                 NORMAL DEPTH M.
PIPE SLOPE
  (SIN)
    0.0017       0.0336     0.0479     0.0594     0.0697     0.0795     0.0840     0.0988     0.1094              0.1500
    0.0025       0.0306     0.0433     0.0535     0.0625     0.0709     0.0790     0.0868     0.0948              0.1500
    0.0033       0.0285     0.0403     0.0497     0.0560     0.0656     0.0728     0.0798     0.0866              0.1500
    0.0050       0.0258     0.0363     0.0446     0.0519     0.0585     0.0646     0.0705     0.0762              0.1500
    0.0066       0.0241     0.0339     0.0416     0.0462     0.0542     0.0599     0.0651     0.0703              0.1500
    0.0100       0.0218     0.0306     0.0374     0.0433     0.0486     0.0535     0.0581     0.0625              0.1500
    0.0125       0.0206     0.0269     0.0354     0.0409     0.0459     0.0504     0.0547     0.0589              0.1500
    0.0250       0.0175     0.0244     0.0298     0.0343     0.0384     0.0422     0.0456     0.0489              0.1500

                                                      ******

    0.0349       0.0161     0.0225     0.0274     0.0316     0.0353     0.0387     0.0419     0.0449              0.1500
    0.0698       0.0137     0.0190     0.0232     0.0266     0.0297     0.0325     0.0351     0.0376              0.1500
    0.1045       0.0124     0.0173     0.0210     0.0242     0.0269     0.0295     0.0318     0.0340              0.1500
    0.1736       0.0110     0.0153     0.0186     0.0213     0.0238     0.0260     0.0280     0.0299              0.1500
    0.3402       0.0094     0.0130     0.0158     0.0162     0.0202     0.0221     0.0238     0.0254              0.1500
    0.5000       0.0086     0.0119     0.0144     0.0166     0.0184     0.0201     0.0217     0.0231              0.1500
    0.7070       0.0079     0.0110     0.0133     0.0152     0.0170     0.0185     0.0199     0.0213              0.1500
    0.8660       0.0076     0.0105     0.0127     0.0145     0.0162     0.0176     0.0190     0.0202              0.1500
    0.9659       0.0074     0.0102     0.0124     0.0142     0.0157     0.0172     0.0185     0.0197              0.1500
    1.0000       0.0073     0.0101     0.0123     0.0140     0.0156     0.0170     0.0183     0.0195              0.1500


CRITICAL         0.0280     0.0400     0.0493     0.0572     0.0643     0.0707     0.0767     0.0821
DEPTH M.
```

```
TABULATED VALUES OF F*M AT NORMAL DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER     0.1500 M. AND MANNING COEFF.


FLOW RATE =     1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000 L/S.     PIPE DIA. OR
                                                                                                   WIDTH M.

                                    F*M VALUE AT NORMAL DEPTH, M.
PIPE SLOPE
  (SIN)
   0.0017       0.7372    1.7665    2.9660    4.3096    5.7904    7.4107    9.2041   11.2255           0.1500
   0.0025       0.7030    1.6662    2.8247    4.0862    5.4579    6.9329    8.5061   10.2006           0.1500
   0.0033       0.6941    1.6674    2.7924    4.0337    5.3741    6.8040    8.3184    9.9185           0.1500
   0.0050       0.7024    1.6934    2.8373    4.0950    5.4468    6.8805    8.3881    9.9597           0.1500
   0.0066       0.7212    1.7440    2.9241    4.2208    5.6137    7.0848    8.5320   10.2404           0.1500
   0.0100       0.7683    1.8642    3.1333    4.5234    6.0198    7.5984    9.2516   10.9717           0.1500
   0.0125       0.8024    1.9519    3.2823    4.7428    6.3096    7.9701    9.7007   11.5005           0.1500
   0.0250       0.9489    2.3208    3.9153    5.6672    7.5473    9.5363   11.6299   13.7930           0.1500

                                              ******

   0.0349       1.0434    2.5548    4.3134    6.2506    8.3254   10.5281   12.8359   15.2213           0.1500
   0.0698       1.2898    3.1649    5.3513    7.7662   10.3665   13.1106   15.9940   18.9736           0.1500
   0.1045       1.4689    3.6083    6.1097    8.8647   11.8299   14.9728   18.2923   21.7196           0.1500
   0.1736       1.7349    4.2754    7.2435   10.5309   14.0482   17.8019   21.7185   25.8130           0.1500
   0.3402       2.1823    5.3783    9.1054   13.2422   17.7099   22.4234   27.3707   32.5169           0.1500
   0.5000       2.4881    6.1371   10.4001   15.1153   20.1848   25.5854   31.2853   37.1610           0.1500
   0.7070       2.8013    6.9135   11.7156   17.0475   22.7701   28.8600   35.2458   41.9394           0.1500
   0.8660       3.0030    7.4151   12.5648   18.2812   24.4377   30.9914   37.8332   45.0414           0.1500
   0.9659       3.1191    7.6896   13.0583   18.9749   25.3953   32.1490   39.3614   46.7453           0.1500
   1.0000       3.1537    7.7922   13.2013   19.2265   25.6997   32.5517   39.6135   47.3810           0.1500
```

APPENDIX 9

JUMP LOCATION IN A 0.15 m DIAMETER PIPE AT SLOPE 1/300, CARRYING 6 ℓ/s, FOR A RANGE OF MANNING COEFFICIENTS 0.009 to 0.018. RESULTS PRESENTED FOR UNIFORM MANNING COEFFICIENTS IN BOTH APPROACH PIPE AND TEST PIPE AND CONSTANT APPROACH PIPE MANNING COEFFICIENT OF 0.015.

```
 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC      HN  ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COEFF (SIN)    M.  ENERGY (SIN)    M.      M.  DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                M.                          M.    M.    N.    M.     M.    M.       M.    M.       M.    N.    M.

 6.0 0.15 0.018 0.0349 0.055 0.107 0.0033 0.071 0.117                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.15 0.018 0.0698 0.046 0.132 0.0033 0.071 0.117                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.15 0.018 0.1045 0.042 0.156 0.0033 0.071 0.117                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.15 0.018 0.1736 0.037 0.201 0.0033 0.071 0.117 0.037  0.2011.218 0.040 0.117  0.076  0.166  0.125 -0.04110.038 0.293

 6.0 0.15 0.018 0.3402 0.031 0.295 0.0033 0.071 0.117 0.031  0.2813.685 0.040 0.117  0.076  0.166  0.125 -0.04110.038 0.535

 6.0 0.15 0.018 0.5000 0.028 0.375 0.0033 0.071 0.117 0.028  0.3615.666 0.040 0.117  0.076  0.166  0.125 -0.04110.038 0.813

 6.0 0.15 0.018 0.7070 0.026 0.469 0.0033 0.071 0.117 0.025  0.4517.550 0.040 0.117  0.076  0.166  0.125 -0.04110.038 0.953

 6.0 0.15 0.018 0.8660 0.025 0.536 0.0033 0.071 0.117 0.025  0.5319.056 0.040 0.117  0.076  0.166  0.125 -0.04110.038 1.073

 6.0 0.15 0.018 0.9659 0.024 0.575 0.0033 0.071 0.117 0.025  0.5319.056 0.040 0.117  0.076  0.166  0.125 -0.04110.038 1.070

 6.0 0.15 0.018 1.0000 0.024 0.589 0.0033 0.071 0.117 0.024  0.5719.900 0.040 0.117  0.076  0.166  0.125 -0.04110.038 1.124
```

Constant n, test and approach pip

```
 COMMON DATA  APPROACH PIPE DATA                              TEST PIPE DATA AND PROGRAM RESULTS.

 Q.   DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC      HN  ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S   M.   COFFF (SIN)    M.  ENERGY (SIN)    M.      M.  DEPTH ENERGY F.N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                                M.                          M.    M.    N.    M.     M.    M.       M.    M.       M.    N.    M.

 6.0 0.15 0.015 0.0349 0.050 0.118 0.0033 0.071 0.101                 JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

 6.0 0.15 0.015 0.0698 0.042 0.153 0.0033 0.071 0.101 0.043  0.15 9.308 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 0.430

 6.0 0.15 0.015 0.1045 0.038 0.186 0.0033 0.071 0.101 0.033  0.1810.681 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 0.938

 6.0 0.15 0.015 0.1736 0.033 0.246 0.0033 0.071 0.101 0.034  0.2412.499 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 1.386

 6.0 0.15 0.015 0.3402 0.028 0.370 0.0033 0.071 0.101 0.023  0.3615.666 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 1.910

 6.0 0.15 0.015 0.5000 0.026 0.475 0.0033 0.071 0.101 0.025  0.4517.550 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.133

 6.0 0.15 0.015 0.7070 0.024 0.597 0.0033 0.071 0.101 0.024  0.5719.900 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.350

 6.0 0.15 0.015 0.8660 0.023 0.683 0.0033 0.071 0.101 0.023  0.5323.815 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.632

 6.0 0.15 0.015 0.9659 0.022 0.735 0.0033 0.071 0.101 0.022  0.5921.807 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.533

 6.0 0.15 0.015 1.0000 0.022 0.752 0.0033 0.071 0.101 0.022  0.6921.807 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.533
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F.M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.M.  POS.
                                M.                          M.    M.    N.    M.     M.    M.       M.     M.      M.    M.    M.

 6.0 0.15 0.012 0.0349 0.045 0.138 0.0033 0.071 0.087 0.045  0.14 3.880 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 1.855
 6.0 0.15 0.012 0.0698 0.038 0.190 0.0033 0.071 0.087 0.035  0.1910.691 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 2.739
 6.0 0.15 0.012 0.1045 0.034 0.237 0.0033 0.071 0.087 0.034  0.2312.150 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 3.332


 6.0 0.15 0.012 0.1736 0.030 0.322 0.0033 0.071 0.087 0.030  0.3214.610 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 4.010
 6.0 0.15 0.012 0.3402 0.025 0.493 0.0033 0.071 0.087 0.025  0.4918.274 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 4.722
 6.0 0.15 0.012 0.5000 0.023 0.636 0.0033 0.071 0.087 0.023  0.6320.815 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 5.059
 6.0 0.15 0.012 0.7070 0.021 0.804 0.0033 0.071 0.087 0.022  0.7522.887 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 5.235
 6.0 0.15 0.012 0.8660 0.020 0.924 0.0033 0.071 0.087 0.020  0.9225.356 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 5.517
 6.0 0.15 0.012 0.9659 0.020 0.994 0.0033 0.071 0.087 0.020  0.9225.356 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 5.517
 6.0 0.15 0.012 1.0000 0.020 1.021 0.0033 0.071 0.087 0.020  0.9225.356 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 5.517
```

Constant n, test and approach pipe

```
 COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

  Q.  DIA. MANN. SLOPE    HN  TERM.  SLOPE    HC     HN  ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
 L/S  M.   COEFF (SIN)    M.  ENERGY (SIN)    M.     M.  DEPTH ENERGY F.M  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.M.  POS.
                                M.                          M.    M.    N.    M.     M.    M.       M.     M.      M.    M.    M.

 6.0 0.15 0.009 0.0349 0.039 0.179 0.0033 0.071 0.073 0.039  0.1810.434 0.069 0.073  0.004  0.098  0.098 -0.000 6.604 8.372
 6.0 0.15 0.009 0.0698 0.033 0.262 0.0033 0.071 0.073 0.033  0.2512.870 0.069 0.073  0.004  0.098  0.098 -0.000 6.604 9.825
 6.0 0.15 0.009 0.1045 0.029 0.335 0.0033 0.071 0.073 0.030  0.3214.610 0.069 0.073  0.004  0.098  0.098 -0.000 6.60410.591
 6.0 0.15 0.009 0.1736 0.026 0.464 0.0033 0.071 0.073 0.025  0.4517.550 0.069 0.073  0.003  0.098  0.098 -0.000 6.60411.756
 6.0 0.15 0.009 0.3402 0.022 0.725 0.0033 0.071 0.073 0.022  0.6921.807 0.069 0.073  0.003  0.098  0.098 -0.000 6.60412.795
 6.0 0.15 0.009 0.5000 0.020 0.939 0.0033 0.071 0.073 0.020  0.9225.356 0.070 0.073  0.003  0.098  0.098 -0.000 6.60413.405
 6.0 0.15 0.009 0.7070 0.019 1.140 0.0033 0.071 0.073 0.019  1.1528.332 0.070 0.073  0.003  0.098  0.098 -0.000 6.60413.808
 6.0 0.15 0.009 0.8660 0.018 1.370 0.0033 0.071 0.073 0.018  1.2930.057 0.070 0.073  0.003  0.098  0.098 -0.000 6.60414.000
 6.0 0.15 0.009 0.9659 0.017 1.474 0.0033 0.071 0.073 0.017  1.4631.972 0.070 0.073  0.003  0.098  0.098 -0.000 6.60414.195
 6.0 0.15 0.009 1.0000 0.017 1.510 0.0033 0.071 0.073 0.017  1.4631.972 0.070 0.073  0.003  0.098  0.098 -0.000 6.60414.195
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COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE   HN   TERM.  SLOPE   HC     HN  ENTRY ENTRY ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)   M.   ENERGY (SIN)   M.     M.  DEPTH ENERGY F-N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE FORM. POS.
                             M.                         M.    M.    M.    M.     M.    M.        M.     M.      M.    M.    M.

6.0 0.15 0.018 0.0349 0.050 0.118 0.0033 0.071 0.117              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

5.0 0.15 0.018 0.0698 0.042 0.153 0.0033 0.071 0.117              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

6.0 0.15 0.018 0.1045 0.038 0.186 0.0033 0.071 0.117 0.039  0.1913.681 0.040 0.117  0.076  0.166  0.125 -0.04110.038 0.189

5.0 0.15 0.018 0.1736 0.033 0.246 0.0033 0.071 0.117 0.034  0.2412.497 0.040 0.117  0.076  0.166  0.125 -0.04110.039 0.450

6.0 0.15 0.018 0.3402 0.028 0.370 0.0033 0.071 0.117 0.028  0.3513.665 0.040 0.117  0.075  0.166  0.125 -0.04110.038 0.818

5.0 0.15 0.018 0.5000 0.026 0.475 0.0033 0.071 0.117 0.025  0.4517.550 0.040 0.117  0.076  0.166  0.125 -0.04110.038 0.959

5.0 0.15 0.018 0.7070 0.024 0.597 0.0033 0.071 0.117 0.024  0.5719.900 0.043 0.117  0.075  0.166  0.125 -0.04110.038 1.124

5.0 0.15 0.018 0.8660 0.023 0.683 0.0033 0.071 0.117 0.023  0.5323.815 0.040 0.117  0.076  0.166  0.125 -0.04110.039 1.175

5.0 0.15 0.018 0.9659 0.022 0.735 0.0033 0.071 0.117 0.022  0.5921.807 0.040 0.117  0.075  0.166  0.125 -0.04110.036 1.227

5.0 0.15 0.018 1.0000 0.022 0.752 0.0033 0.071 0.117 0.022  0.5921.807 0.040 0.117  0.075  0.166  0.125 -0.04110.039 1.227
```

Approach pipe n = 0.015

```
COMMON DATA  APPROACH PIPE DATA                          TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE   HN   TERM.  SLOPE   HC     HN  ENTRY ENTRY.ENTRY UPJUMP JUMP  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)   M.   ENERGY (SIN)   M.     M.  DEPTH ENERGY F-N  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE FORM. POS.
                             M.                         M.    M.    N.    M.     M.    M.        M.     M.      M.    M.    M.

5.0 0.15 0.015 0.0349 0.050 0.118 0.0033 0.071 0.101              JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.

6.0 0.15 0.015 0.0698 0.042 0.153 0.0033 0.071 0.101 0.043  0.15 7.380 0.043 0.101  0.052  0.125  0.112 -0.013 8.309 0.499

5.0 0.15 0.015 0.1045 0.036 0.186 0.0033 0.071 0.101 0.039  0.1913.681 0.048 0.101  0.052  0.125  0.112 -0.013 8.339 0.988

6.0 0.15 0.015 0.1736 0.033 0.246 0.0033 0.071 0.101 0.034  0.2412.499 0.043 0.101  0.052  0.125  0.112 -0.013 8.339 1.385

5.0 0.15 0.015 0.3402 0.028 0.370 0.0033 0.071 0.101 0.028  0.3613.663 0.046 0.101  0.052  0.125  0.112 -0.013 8.339 1.910

5.0 0.15 0.015 0.5000 0.026 0.475 0.0033 0.071 0.101 0.025  0.4517.550 0.043 0.101  0.052  0.125  0.112 -0.013 8.339 2.139

5.0 0.15 0.015 0.7070 0.024 0.597 0.0033 0.071 0.101 0.024  0.5719.900 0.048 0.101  0.052  0.125  0.112 -0.013 8.339 2.350

5.0 0.15 0.015 0.8660 0.023 0.683 0.0033 0.071 0.101 0.023  0.6323.815 0.048 0.101  0.052  0.125  0.112 -0.013 8.309 2.432

6.0 0.15 0.015 0.9659 0.022 0.735 0.0033 0.071 0.101 0.022  0.5921.807 0.048 0.101  0.052  0.125  0.112 -0.013 8.339 2.503

5.0 0.15 0.015 1.0000 0.022 0.752 0.0033 0.071 0.101 0.022  0.6921.807 0.046 0.101  0.052  0.125  0.112 -0.013 8.307 2.503
```

```
COMMON DATA  APPROACH PIPE DATA                        TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N.  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                          M.    M.     N.    M.     M.    M.         M.    M.      M.    N.    %.

6.0 0.15 0.012 0.0349 0.050 0.118 0.0033 0.071 0.087 0.051  0.12 7.894 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 0.793
6.0 0.15 0.012 0.0698 0.042 0.153 0.0033 0.071 0.087 0.043  0.15 9.380 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 2.009
5.0 0.15 0.012 0.1045 0.038 0.186 0.0033 0.071 0.087 0.035  0.1910.681 0.057 0.087  0.030  0.105  0.103 -0.002 7.271 2.789


6.0 0.15 0.012 0.1736 0.033 0.246 0.0033 0.071 0.087 0.030  0.2412.499 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 3.422
6.0 0.15 0.012 0.3432 0.028 0.370 0.0033 0.071 0.087 0.028  0.3613.665 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 4.243
5.0 0.15 0.012 0.5000 0.026 0.475 0.0033 0.071 0.087 0.026  0.4517.550 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 4.605
5.0 0.15 0.012 0.7070 0.024 0.597 0.0033 0.071 0.087 0.024  0.5719.909 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 4.956
5.0 0.15 0.012 0.8660 0.023 0.683 0.0033 0.071 0.087 0.023  0.5323.815 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 5.059
6.0 0.15 0.012 0.9659 0.022 0.735 0.0033 0.071 0.087 0.022  0.6921.807 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 5.182
5.0 0.15 0.012 1.0000 0.022 0.752 0.0033 0.071 0.087 0.022  0.5921.807 0.057 0.087  0.029  0.105  0.103 -0.002 7.271 5.182
```

Approach pipe n = 0.015

```
COMMON DATA  APPROACH PIPE DATA                        TEST PIPE DATA AND PROGRAM RESULTS.

 Q.  DIA. MANN. SLOPE    HN   TERM.  SLOPE    HC     HN   ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY JUMP  JUMP
L/S  M.   COEFF (SIN)    M.   ENERGY (SIN)    M.     M.   DEPTH ENERGY F.N.  DEPTH  DEPTH CHANGE UPJUMP DOWN   CHANGE F.N.  POS.
                              M.                          M.    M.     N.    M.     M.    M.         M.    M.      M.    N.    %.

6.0 0.15 0.009 0.0349 0.050 0.118 0.0033 0.071 0.073 0.051  0.12 7.894 0.059 0.073  0.004  0.098  0.098 -0.003 6.604 4.538
6.0 0.15 0.009 0.0698 0.042 0.153 0.0033 0.071 0.073 0.043  0.15 9.380 0.064 0.073  0.004  0.098  0.098 -0.003 6.604 6.333
5.0 0.15 0.009 0.1045 0.038 0.186 0.0033 0.071 0.073 0.034  0.1910.681 0.059 0.073  0.004  0.098  0.099 -0.003 6.604 8.293
6.0 0.15 0.009 0.1736 0.033 0.246 0.0033 0.071 0.073 0.030  0.2412.499 0.057 0.073  0.004  0.093  0.093 -0.003 6.604 9.508
5.0 0.15 0.009 0.3432 0.028 0.370 0.0033 0.071 0.073 0.028  0.3615.066 0.067 0.073  0.004  0.095  0.096 -0.003 6.60411.119
6.0 0.15 0.009 0.5000 0.026 0.475 0.0033 0.071 0.073 0.025  0.4517.550 0.064 0.073  0.003  0.093  0.098 -0.003 6.60411.756
5.0 0.15 0.009 0.7070 0.024 0.597 0.0033 0.071 0.073 0.024  0.5719.900 0.060 0.073  0.003  0.099  0.099 -0.006 6.60412.303
6.0 0.15 0.009 0.8660 0.023 0.683 0.0033 0.071 0.073 0.023  0.5323.815 0.057 0.073  0.003  0.093  0.098 -0.003 6.60412.590
5.0 0.15 0.009 0.9659 0.022 0.735 0.0033 0.071 0.073 0.022  0.5921.807 0.057 0.073  0.003  0.098  0.099 -0.000 6.60412.795
5.0 0.15 0.009 1.0000 0.022 0.752 0.0033 0.071 0.073 0.022  0.5921.807 0.064 0.073  0.003  0.093  0.098 -0.003 6.60412.795
```

APPENDIX 10

SAMPLE OUTPUT PROGRAM HYDJUMP. THE OUTPUT CONTROL PARAMETER SET TO GIVE WATER SURFACE PROFILES IN BOTH THE APPROACH PIPE AND UPSTREAM AND DOWNSTREAM OF THE JUMP IN THE TEST PIPE

```
PREDICTION OF THE HYDRAULIC
JUMP POSITION IN A CIRCULAR
CROSS SECTION PIPE AT MILD SLOPE.




PIPE LENGTH =     2.0000 M.      PIPE WIDTH OR DIAMETER =    0.1500 M.
MANNING COEFF. =     0.0120      PIPE SLOPE =    0.5000
FLOWRATE =    0.0060 M**3/S.     CONTROL DEPTH =     0.0707 M.


NORMAL DEPTH =     0.0231 M.     CRITICAL DEPTH =    0.0707 M.


CONTROL IS UPSTREAM, DEPTH =     0.0707 M.



DISTANCE      DEPTH      ENERGY      F+M
  0.          0.0707     0.0980      6.7950
  0.0001      0.0691     0.0981      6.8004
  0.0005      0.0675     0.0983      6.8173
  0.0014      0.0660     0.0987      6.8463
  0.0026      0.0644     0.0993      6.8881
  0.0042      0.0628     0.1001      6.9436
  0.0063      0.0612     0.1011      7.0135
  0.0090      0.0596     0.1024      7.0990
  0.0123      0.0581     0.1041      7.2010
  0.0163      0.0565     0.1060      7.3209
  0.0212      0.0549     0.1084      7.4601
  0.0271      0.0533     0.1113      7.6201
  0.0342      0.0517     0.1146      7.8029
  0.0425      0.0501     0.1186      8.0104
  0.0525      0.0486     0.1234      8.2452
  0.0643      0.0470     0.1289      8.5100
  0.0783      0.0454     0.1355      8.8079
  0.0950      0.0438     0.1433      9.1428
  0.1150      0.0422     0.1524      9.5191
  0.1390      0.0406     0.1633      9.9418
  0.1630      0.0391     0.1762     10.4171
  0.2033      0.0375     0.1916     10.9524
  0.2469      0.0359     0.2100     11.5562
  0.3012      0.0343     0.2321     12.2393
  0.3702      0.0327     0.2590     13.0146
  0.4600      0.0311     0.2917     13.8981
  0.5807      0.0296     0.3321     14.9094
  0.7516      0.0280     0.3823     16.0736
  1.0150      0.0264     0.4453     17.4224
  1.5032      0.0248     0.5256     18.9969
  2.0000      0.0246     0.5401     19.2662
```

```
PIPE LENGTH =   40.0000 M.       PIPE WIDTH OR DIAMETER =    0.1500 M.
MANNING COEFF. =    0.0120       PIPE SLOPE =    0.0033
FLOWRATE =    0.0060 M**3/S.     CONTROL DEPTH =    0.0247 M.


NORMAL DEPTH =    0.0865 M.      CRITICAL DEPTH =    0.0707 M.


CONTROL IS UPSTREAM, DEPTH =    0.0247 M.



DISTANCE      DEPTH      ENERGY     F+M
  0.          0.0247     0.5286   19.0558
  0.4772      0.0278     0.3879   16.1981
  0.9597      0.0309     0.2978   14.0538
  1.4445      0.0339     0.2376   12.4072
  1.9237      0.0370     0.1966   11.1211
  2.4095      0.0401     0.1676   10.1048
  2.8931      0.0431     0.1470    9.2958
  3.3459      0.0462     0.1320    8.6501
  3.7936      0.0493     0.1211    8.1359
  4.2212      0.0523     0.1133    7.7294
  4.6222      0.0554     0.1076    7.4131
  4.9333      0.0585     0.1036    7.1731
  5.3102      0.0615     0.1009    6.9988
  5.5722      0.0646     0.0992    6.8820
  5.7538      0.0677     0.0983    6.8158
  5.8237      0.0707     0.0980    6.7950
```

```
PIPE LENGTH =    40.0000 M.       PIPE WIDTH OR DIAMETER =    0.1500 M.
MANNING COEFF. =    0.0120        PIPE SLOPE =    0.0033
FLOWRATE =    0.0060 M**3/S.      CONTROL DEPTH =    0.0707 M.


NORMAL DEPTH =    0.0865 M.       CRITICAL DEPTH =    0.0707 M.


CONTROL IS DOWNSTREAM, DEPTH =    0.0707 M.




DISTANCE     DEPTH      ENERGY      F+M
  0.         0.0707     0.0980      6.7950
  0.0104     0.0718     0.0981      6.7974
  0.0429     0.0728     0.0982      6.8047
  0.1014     0.0739     0.0983      6.8164
  0.1906     0.0750     0.0985      6.8326
  0.3169     0.0760     0.0987      6.8521
  0.4330     0.0771     0.0990      6.8768
  0.7146     0.0781     0.0993      6.9056
  1.0120     0.0792     0.0997      6.9383
  1.4023     0.0803     0.1001      6.9749
  1.9202     0.0813     0.1005      7.0151


  2.6237     0.0824     0.1009      7.0591
  3.6227     0.0834     0.1014      7.1066
  5.1555     0.0845     0.1019      7.1576
  8.0673     0.0856     0.1025      7.2119
 40.0000     0.0866     0.1030      7.2696



JUMP POSITION          =    4.8547 M FROM PIPE ENTRY.
CONJUGATE DEPTHS       =    0.0573 M UPSTREAM AND 0.0865M DOWNSTREAM.
KINETIC ENERGY VALUE   =    0.1051M UPSTREAM AND    0.1029 M DOWNSTREAM.
HYDROSTATIC+MOMENTUM   =    7.2612 N.

DEPTH CHANGE AT JUMP   =    0.29116E-01 M.
ENERGY LOSS AT JUMP    =   -0.21271E-02 M.
```

APPENDIX 11

PROGRAM HYDJUMP

PROGRAM HYDJUMP

A full print out of HYDJUMP is included in this appendix. The program was written in Fortran for use on the NBS CBT Perkin Elmer 732 computer. No special facilities are required, single precision sufficient.

The program contains numerous comment blocks describing the calculation technique, however a simple flow diagram is included in this appendix.

Input data to the program is simple, the program being designed to carry out numerous repeat passes to generate the tabular data included in earlier appendices. In order to facilitate use, a set of example data is included in this appendix for a number of options.

It should be noted that all calculations are carried out in SI units. All input data are in SI units with the exception of flow rate; this is entered in litres/s and converted within the program to m^3/s.

HYJUMP Schematic flow diagram.

Read output control IOUT
1 = summary tables only
0 = water surface profiles.

↓

Read channel shape control SHAPE
1 = rectangular, 2 = circular.

↓

B.

Read NN, NS, ICON
NN-determines size of Δh in Simpsons Rule
NS- No of steps necessary to complete water surface profile in Simpsons Rule.
ICON - calculation control,
= 0 Approach pipe surface profile calc.
= 1 Pipe entry energy as input data.
= 2 Terminal conditions assumed in approach pipe plus normal flow depth downstream jump in test pipe.

From C.

↓

Read B, RMØ, RM1, DEN
B = pipe diameter or channel width
RMØ = approach pipe Manning Coeff.
RM1 = test pipe Manning Coeff.
DEN = loss factor at test pipe entry, 0-1.0

↓

Write titles.

↓

Set pipe count IZ = 0

↓

A. Read PL, S0, Q, HCONT, ENZ
PL - pipe length, S0 - pipe slope
Q - flow rate, HCONT - calc. control,
= 0, control depths set to flow
critical depth values ; = 1, control depth
at pipe entry to be calculated.
ENZ - pipe entry energy, = 0 if ICON = 0 or 2.

From F, G, H.

E. Check PL, = 0 GOTO C, >0 GOTO D

D. Set pipe count IZ = IZ + 1
1 = approach pipe
2 = test pipe upstream jump
3 = " " downstream "

From E

If IZ > 3, IZ set to 1.

Check ICON, IZ = 1

ICON = 0, 2.

ICON = 1
Calculate pipe entry depth
from entry energy ENZ
and flow rate Q.
Set pipe count to 2

Calculate normal and critical flow
depth h_n, h_c.

Determine control depth position,
from HCONT input.

F. Calculation abort checks,
$h_n > B$ for IZ = 2, full bore flow, GOTO A
$h_n > B$ for IZ = 3, " " " , GOTO A
$h_n < h_c$ for IZ = 2 and 3, no jump, GOTO A.

Calculate water surface profiles, check ICON, IZ values.

ICON = 0, IZ = 1,2,3
Calculate water surface profiles

ICON = 2, IZ = 1
Terminal conditions in approach pipe,
set depth = h_n, energy = $h_n + Q^2/2gA_n^2$

ICON = 2, IZ = 3
Normal flow depth downstream jump
Set depth = h_n, calculate $(F+M)_n$.

ICON = 1, IZ = 2, 3
Calculate water surface profiles.

(Note (F+M) values calculated with water surface profiles)

Jump location determination.

G. Abort check, if (F+M) IZ = 3, L = 0
$>$ (F+M) IZ = 1, terminal value then write
"jump drowned", GOTO A

Check ICON

ICON = 2	ICON < 2
Employ (F+M) at normal depth for IZ = 3 as interpolation target on (F+M) profile IZ = 2	Use full intersection (F+M) curve technique for IZ = 2, 3.

```
           Write out results, format control
            IOUT = 1 , summary tables only
              |  = 0 , water surface profiles.
              ↓
From |   H. GOTO A
 E   ↓

   C.     Read  SHAPE     = 0  run terminated
                          > 0  GOTO B
```

Example DATA program HYDJUMP

Case 1 Rectangular and circular channels, 2 approach pipe slopes. Note ▽ indicates space in format field.

Line 1 IOUT, Format I3
▽▽0 (full output)
Line 2 SHAPE, Format I3
▽▽1 (rectangular section)
Line 3 NN, NS, ICON, Format 3I4
▽▽30▽200▽▽▽0
Line 4 B, RMφ, RMI, DEN, Format 4F10.4
▽▽▽▽0.1500▽▽▽▽0.0150▽▽▽▽0.0150▽▽▽▽1.0000
Line 5 PL, Sφ, Q, HCONT, ENZ, Format 5F10.4
(approach pipe data)
▽▽▽▽2.0000▽▽▽▽▽0.5000▽▽▽▽6.0000▽▽▽▽0.0000▽▽▽▽0.C
Line 6 PL, Sφ, Q, HCONT, ENZ, Format 5F10.4
▽▽▽40.0000▽▽▽▽0.0025▽▽▽▽6.0000▽▽▽▽1.0000▽▽▽▽▽0.c
(test pipe, upstream jump)
Line 7 PL, Sφ, Q, HCONT, ENZ Format 5F10.4
▽▽▽40.0000▽▽▽▽0.0025▽▽▽▽6.0000▽▽▽▽0.0000▽▽▽▽0.0C
(test pipe, downstream jump)

Line 8 Repeat Line 5, Sφ = approach slope set ▽▽▽▽0.5
Line 9 Repeat Line 6
Line 10 Repeat Line 7

Line 11 PL, Sφ, Q, HCONT, ENZ, Format 5F10.4
▽▽▽▽0.0000▽▽▽▽0.0000 . . . . .
(indicates end data section)

Line 12 SHAPE Format I3
▽▽2 (circular section)
Line 13 – 21 Repeat Line 3 – 11

Line 22 SHAPE Format I3
▽▽0 indicates end of data file.

Case 2	Repeat case 1 but summary data only required.
Line 1	IOUT, Format I3 ▽▽1
Line 2-22	as Case 1
Case 3.	Repeat case 1 but terminal conditions assumed in approach pipe, normal flow downstream jump in test pipe.
Line 1-2	Repeat case 1
Line 3	NN, NS, ICON, Format 3I4 ▽▽30▽200▽▽▽2
Line 4-22	Repeat case 1.
Case 4	Manning coefficient 0.015 approach pipe but 0.009 in test pipe.
Line 1-3	Repeat case 1
Line 4	B, RMØ, RMI, DEN, format 4F10.4 ▽▽▽▽0.1500▽▽▽▽0.0150▽▽▽▽0.0090▽▽▽▽1.000
Line 5-13	Repeat case 1
Line 14	Repeat Line 4 above.
Line 14-22	Repeat case 1

```
$DAIC.1
C
C
C       PROGRAM HYDJUMP REFERS TO A PROGRAM DESIGNED TO
C       CALCULATE THE HYDRAULIC JUMP POSITION AFTER A CHANGE IN
C       SLOPE IN EITHER A RECTANGULAR OR CIRCULAR CROSS
C       SECTION PIPE.
        DIMENSION X(2,100),F(2,100),FP(2,2),IM(6)
        DIMENSION DP(2,2),EN(2,100),DEP(2,100),IP(2),HJ(2),EJ(2)
        DIMENSION QT(300),S1(300),HN1(300),S2(300),HC2(300)
        DIMENSION HN2(300),TEN1(300),EEN(300),HEN(300),HUP(300)
        DIMENSION HDN(300),EUP(300),EDN(300),DFPM(300)
        DIMENSION FFM(300),DJM(300),DEJ(300),XJUMP(300)
        INTEGER SHAPE
        COMMON/CM1/B,Q,G,CON,SO,GAM,RHO,HCRIT,HNORM,AREA,PER,FPM,ENERG
        COMMON/CM2/SHAPE
        COMMON/CM3/IZ
        READ(4,702)IOUT
        READ(4,702)SHAPE
C       IOUT IS A OUTPUT FORMAT CONTROL CODE,=1 ONLY OUTPUT
C       IS A SUMMARY TABLE,=0 OUTPUT INCLUDES WATER SURFACE
C       PROFILES.
702     FORMAT(I3)
902     READ(4,120)NN,NS,ICON
        READ(4,121)B,RHO,RM1,DEN
121     FORMAT(4F10.4)
        G=9.81
C
C
C
C
C
C
C
C
C
        IC=0
        ICOUNT=0
        IZ=0
300     CONTINUE
        IF(IZ.EQ.3) GOTO 9010
9011    CONTINUE
        IF(IZ.GT.1)IM(IZ)=IS
        IZ=IZ+1
        IF(IZ.EQ.1)WRITE(3,504)
504     FORMAT(1H1,/////)
        IF(IZ.EQ.1.AND.SHAPE.EQ.1)WRITE(3,505)
505     FORMAT(///////////,20X,'PREDICTION OF THE HYDRAULIC',
       1/,20X,'JUMP POSITION IN A RECTANGULAR',/20X,
       2'CROSS SECTION PIPE AT MILD SLOPE.',///////)
        IF(SHAPE.EQ.2.AND.IZ.EQ.1)WRITE(3,500)
500     FORMAT(20X,'PREDICTION OF THE HYDRAULIC',/,20X,
       1'JUMP POSITION IN A CIRCULAR',/,20X,
       2'CROSS SECTION PIPE AT MILD SLOPE.',/////)
        IF(IZ.GT.3)IZ=1
        IF(IZ.EQ.1)IC=IC+1
        READ(4,100)PL,SO,Q,HCONT,ENZ
C
C
C
C
C
```

```
C
C     IF ICON=2 THE ANALYSIS IS BASED ON THE ASSUMPTION OF
C     TERMINAL FLOW CONDITIONS AT THE DISCHARGE FROM THE
C     APPROACH PIPE.
C     ICON = 2 ALSO INTRODUCES THE CONSTRAINT THAT THE
C     TEST PIPE IS LONG ENOUGH FOR NORMAL FLOW DEPTH
C     TO BE ESTABLISHED DOWNSTREAM OF THE JUMP. NORMAL
C     DEPTH THEN BECOMES THE DOWNSTREAM CONJUGATE DEPTH
C     WHICH ALLOWS CALCULATION OF THE 'F+M' TERM WITHOUT
C     CALCULATING THE WATER SURFACE PROFILE DOWNSTREAM OF THE
C     JUMP.
C     IF ICON=1 THE FLOW ANALYSIS IS BASED ON AN INPUT ENERGY AT
C     ENTRY TO THE MILD SLOPE PIPE, TERM ENZ. SIMILARLY THE LOSS
C     COEFFICIENT AT PIPE ENTRY MAY BE EXPRESSED AS A FACTOR,DEN,
C     VALUE 0 TO 1.0, TO BE MULTIPLIED BY THE ENZ TERM.
C     AS THE ENTRY FLOW DEPTH IS TO BE CALCULATED FROM ENZ*DEN
C     AND NOT BASED ON FLOW CRITICAL DEPTH, THE CONTROL TERM
C     HCONT IS SET TO 1.0. THE OTHER PARAMETERS REFER TO PIPE FLOW
C     RATE AND DIMENSIONS.
100   FORMAT(5F10.4)
      IF(PL.EQ.0.0)GOTO 901
C     PL-PIPE LENGTH, B-WIDTH, RM-MANNING COEFF, SO-SLOPE,
C     Q-FLOWRATE IN L/S TO BE USED IN M**3/S, HCONT-CONTROL DEPTH
C     SET TO ZERO IF CRITICAL DEPTH ASSUMED.
      Q=Q/1000.0
      RHO=1000.0
      IF(IZ.EQ.1) RM=RM0
      IF(IZ.GT.1) RM=RM1
      CON=RM**2/SO
      GAM=G*RHO
C
C
C
      QT(IC)=Q*1000.0
      IF(IZ.EQ.1)S1(IC)=SO
      IF(IZ.EQ.2)S2(IC)=SO
C     PROGRAM CONTROL DATA.
120   FORMAT(3I4)
C     NN-SIZE OF THE DH STEP IN SIMPSONS RULE,NS-NO.
C     STEPS IN DEPTH CALC.,ICON DETERMINES WHETHER ENERGY
C     INPUT OR UPSTREAM SLOPE IS USED, DEN IS THE ENERGY
C     LOSS FACTOR FOR THE PIPE ENTRY,IN EITHER ENTRY CASE.
C     ENZ-INPUT ENERGY TO REPLACE SLOPE IF ICON = 1.
      IF (ICON.EQ.1) GOTO 650
      GOTO 651
650   ENZ=DEN*ENZ
      CALL BOUND(ENZ,Q,B,HB)
      IZ=2
      HCONT=HB
      GOTO 18
651   CONTINUE
      IF(HCONT.EQ.1.0) GOTO 17



      GOTO 18
17    ENGD=DEN*ENGD
      CALL BOUND(ENGD,Q,B,HB)
      HCONT=HB
18    CONTINUE
C
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CC
C      DETERMINATION OF CRITICAL AND NORMAL DEPTHS.
C      THIS SECTION CALCULATES THE NORMAL AND CRITICAL DEPTH IN
C      EACH PIPE LENGTH FOR LATER COMPARISON TO THE CONTROL DEPTH
C      INPUT.
C      CALCULATION OF CRITICAL DEPTH.
       UP=B
       DN=0.0
       HC=UP/2.0
7      CONTINUE
       CALL CALC(HC,DL)
       IF(HCRIT)3,4,5
3      DN=HC
       GOTO 6
5      UP=HC
6      HCN=(UP+DN)/2.0
       IF(ABS((HCN-HC)/HC).LE.0.001) GOTO 8
       HC=HCN
       GOTO 7
8      HC=HCN
4      IF(HCONT.EQ.0.0)HCONT=HC
C      CALCULATION OF NORMAL DEPTH.
       UP=B
       DN=0.0
       HN=UP/2.0
9      CONTINUE
       CALL CALC(HN,DL)
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C
       IF(HNORM) 10,11,12
10     DN=HN
       GOTO 13
12     UP=HN
13     HNN=(UP+DN)/2.0
       IF(ABS((HNN-HN)/HN).LE.0.001) GOTO 14
       HN=HNN
       GOTO 9
14     HN=HNN
11     CONTINUE
       IF(IOUT.EQ.1) GOTO 310
       WRITE(3,200)PL,B,KM,SO,Q,HCONT
```

```
200   FORMAT(////20X,'PIPE LENGTH =',F10.4,' M.',5X,
     1'PIPE WIDTH OR DIAMETER =',F10.4,' M.',/,20X,'MANNING COEFF. =',
     2F10.4,5X,'PIPE SLOPE =',F10.4,/,20X,'FLOWRATE =',
     3F10.4,' M**3/S.',3X,'CONTROL DEPTH =',F10.4,' M.',//)
      WRITE(3,201)HN,HC
201   FORMAT(20X,'NORMAL DEPTH =',F10.4,' M.',4X,'CRITICAL DEPTH =',
     1F10.4,' M.',//)
C     FORMATION OF A HYDRAULIC JUMP REQUIRES THAT DEPTH
C     CHANGES FROM BELOW CRITICAL TO ABOVE CRITICAL, HENCE
C     IF NORMAL DEPTH IS LESS THAN CRITICAL NO JUMPFORMS.
      IF(IZ.GT.1.AND.HN.LE.HC)WRITE(3,209)
209   FORMAT(/,20X,'JUMP FORMATION IMPOSSIBLE AS HN<HC.',/)
310   CONTINUE
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C
      IF(IZ.EQ.1)HN1(IC)=HN
      IF(IZ.GT.1)HN2(IC)=HN
      IF(IZ.GT.1)HC2(IC)=HC
      IF(IZ.GT.1.AND.HN.LE.HC)GOTO 800
C     FULL BORE FLOW IS NOT DEALT WITH BY THIS PROGRAM.
C     IF THE VALUE OF HN > PIPE DIAMETER SOLUTION IS
C     TERMINATED.
      IF(IZ.EQ.3.AND.ICON.EQ.2) GOTO 946
      GOTO 947
C     IF THE TEST PIPE IS LONG THEN A CONSIDERABLE SIMPLIFICATION IS
C     POSSIBLE AS THE FLOW DEPTH MAY BE ASSUMED TO BE 'NORMAL'
C     DEPTH AND THE (F+M) VALUE AT THE JUMP IS FIXED.
946   CALL CALC(HN,DL)
      FX=FPM
      EX2=ENERG
      HX2=HN
      HLIM=B*0.99
      IF(HN.GE.HLIM) HN2(IC)=B
      IF(HN.GE.HLIM) GOTO 800
      DO 949 J6=1,IS-1
C      IF THE F+M TERM AT ENTRY IS LESS THAN THE F+M VALUE
C      FOR THE NORMAL FLOW DEPTH THIS INDICATES THAT THE
C      JUMP HAS MOVED TO L=0 AS A DROWNED JUMP.
      FEN(IC)=F(1,1)
      IF(FX.GT.F(1,1)) GOTO 330
      IF(F(1,J6).GE.FX.AND.F(1,J6+1).LE.FX) GOTO 948
949   CONTINUE
C
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      HX1=DEP(1,J6)+R*(DEP(1,J6+1)-DEP(1,J6))
      EX1=EN(1,J6)+R*(EN(1,J6+1)-EN(1,J6))
      CHH=HN-HX1
      CHE=EX2-EX1
      IF(IOUT.EQ.1) GOTO 311
      WRITE(3,952)
952   FORMAT(/20X,'TEST PIPE ASSUMED LONG,NORMAL FLOW DEPTH ',
     1'ESTABLISHED DOWNSTREAM OF THE JUMP.',/)
      WRITE(3,107)XX,HX1,HX2,EX1,EX2,FX,CHH,CHE
      GOTO 800
311   CONTINUE
      HUP(IC)=HX1
      HDN(IC)=HN
      EUP(IC)=EX1
      EDN(IC)=EX2
      DJH(IC)=CHH
      DEJ(IC)=CHE
      CFPM(IC)=FX
      XJUMP(IC)=XX
      GOTO 800
330   IF(IOUT.EQ.0) WRITE(3,332)
332   FORMAT(/20X,'JUMP DROWNED AT L=0',/)
      FEN(IC)=F(1,1)
      CFPM(IC)=FX
      GOTO 800
C
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C
947   CONTINUE
C     THE APPROACH PIPE LENGTH MAY BE IGNORED IF TERMINAL
C     CONDITIONS ARE ASSUMED. THIS SECTION USES THIS OPTION
C     BY CHECKING ON THE PIPE NUMBER ,IZ, AND THE VALUE OF
C     ICON WHICH IS SET TO 2
      IF(IZ.EQ.1.AND.ICON.EQ.2) GOTO 943
      GOTO 945
943   H=HN
      CALL CALC(H,DL)
      ENGD=ENERG
      IF(IOUT.EQ.1)GOTO 312
      WRITE(3,944)H,ENGD
944   FORMAT(/20X,'TERMINAL VELOCITY CONDITIONS IN APPROACH PIPE.',
     1/20X,'DEPTH = ',F10.4,' M.',5X,'ENERGY = ',F10.4,' M.',/)
      GOTO 800
312   CONTINUE
      TEN1(IC)=ENGD
      GOTO 800
945   CONTINUE
      HLIM=0.99*B
      IF(IOUT.EQ.1) GOTO 313
      IF(IZ.GT.1.AND.HN.GE.HLIM)WRITE(3,790)
313   IF(HN.GE.HLIM) HN2(IC)=B
      IF(IZ.GT.1.AND.HN.GE.HLIM)GOTO 800
C
```

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C
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C
C     THIS SECTION PREPARES FOR THE PROFILE CALCULATIONS
C     BY SORTING FLOWS BASED ON PIPE SLOPE AND THE NORMAL AND
C     CRITICAL DEPTH VALUES.
      IF(HN.LT.HC) GOTO 50
C     MILD SLOPE.
      IF(HCONT.LT.HC) GOTO 45
C     SUBCRITICAL FLOW, HCONT GT. HC.
      SIGN=-1.0
      DH=(HCONT-HN)*0.998/FLOAT(NN)
      IF(IOUT.EQ.0) WRITE(3,202)HCONT
202   FORMAT(20X,'CONTROL IS DOWNSTREAM, DEPTH =',F10.4,' M.')
      GOTO 60
C     SUPERCRITICAL FLOW, HCONT LT. HC.
45    SIGN=1.0
      DH=(HC-HCONT)/FLOAT(NN)
      IF(IOUT.EQ.0) WRITE(3,203)HCONT
203   FORMAT(20X,'CONTROL IS UPSTREAM, DEPTH =',F10.4,' M.')
      GOTO 60
C     STEEP SLOPE, HN LT HC.
50    IF(HCONT.LE.HC) GOTO 55
C     SUBCRITICAL FLOW, HCONT GT HC.
      SIGN=-1.0
      DH=(HCONT-HC)/FLOAT(NN)
      IF(IOUT.EQ.0) WRITE(3,202)HCONT
      GOTO 60
C
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C
C     SUPERCRITICAL FLOW, HCONT LT HC.
55    SIGN=1.0
      N2=NN*2
      DH=(HN-HCONT)*0.998/FLOAT(N2)
      IF(IOUT.EQ.0) WRITE(3,203)HCONT
60    SL=0.0
      IS=1
      H=HCONT
      CALL CALC(H,DL)
      E=ENERG
      FM=FPM
      IF(IZ.GT.1)F(IZ-1,IS)=FM
      IF(IZ.EQ.2)X(1,IS)=0.0
      IF(IZ.EQ.3)X(2,IS)=PL
      IF(IZ.GT.1)DEP(IZ-1,IS)=H
      IF(IZ.GT.1)EN(IZ-1,IS)=E
      IF(IOUT.EQ.1) GOTO 314
      WRITE(3,204)
204   FORMAT(////,19X,' DISTANCE ','   DEPTH   ','   ENERGY   ','  F+M')
      WRITE(3,205)SL,H,E,FM
205   FORMAT(18X,4F10.4)
314   IF(IZ.EQ.2)HEN(IC)=H
      IF(IZ.EQ.2)EEN(IC)=E
C
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C
C     WATER SURFACE PROFILE CALCULATIONS USING SIMPSONS RULE
C     TO EVALUATE THE INTEGRAL.
      DO 80 I=1,NS,2
      SLO=SL
      IS=IS+1
      H2=HCONT+SIGN*DH*FLOAT(I+1)
      H3=HCONT+SIGN*FLOAT(I)*DH
      CALL CALC(H,DL)
      CALL CALC(H2,DL2)
      CALL CALC(H3,DL3)
      DX=DH*(DL+DL2+4.0*DL3)/3.0
      SL=SL+DX
      IF(SL.GE.PL)GOTO 82
      H=H2
      CALL CALC(H,DL)
      E=ENERG
      FM=FPM
904   CONTINUE
      IF(IZ.EQ.1.AND.H.LE.HN)GOTO 911
      GOTO 912
911   SL=PL
      H=HN
      CALL CALC(H,DL)
      E=ENERG
      FM=FPM
912   CONTINUE
      IF(IZ.EQ.3.AND.H.GE.3) GOTO 811
      HHX=ABS((H-HN)/HN)
      IF(IZ.EQ.3.AND.HHX.LE.0.001)SL=PL
811   CONTINUE
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      IF(IZ.GT.1)F(IZ-1,IS)=FM
      IF(IZ.EQ.2)X(1,IS)=SL



      IF(IZ.EQ.3)X(2,IS)=PL-SL
      IF(IZ.GT.1)DEP(IZ-1,IS)=H
      IF(IZ.GT.1)EN(IZ-1,IS)=E
      IF(IZ.EQ.2.AND.H.GT.HC) GOTO 800
      IF(IZ.EQ.3.AND.H.GE.B) GOTO 806
      IF(IOUT.EQ.1) GOTO 315
      WRITE(3,205)SL,H,E,FM
315   CONTINUE
      IF(IZ.EQ.1.AND.SL.GE.PL) GOTO 801
      IF(IZ.EQ.1.AND.SL.LE.SLO) GOTO 801
      IF(IZ.EQ.3.AND.SL.GE.PL) GOTO 900
30    CONTINUE
801   ENGD=E
      IF(IZ.EQ.3) GOTO 900
      GOTO 800
32    H=H2-SIGN*2.0*DH*(SL-PL)/DX
      CALL CALC(H,DL)
      E=ENERG
      FM=FPM
      ENGD=E
      SL=PL
      GOTO 904
806   CONTINUE
C
C
CC
C
C     THIS SECTION DEALS WITH THE POSSIBILITY OF FULL BORE FLOW
C     BECOMING ESTABLISHED IN THE PIPE DOWNSTREAM OF THE JUMP
C     LOCATION. THE POSITION OF THE HYDRAULIC JUMP IS
C     DETERMINED BY EQUIVALENCE OF THE F+M TERM BETWEEN THE
C     FULL BORE FLOW AND THE UPSTREAM SUPERCRITICAL FLOW.
      IF(SHAPE.EQ.1) AREA=B**2
      IF(SHAPE.EQ.2) AREA=(3.142*B**2)/4.0
      IF(IOUT.EQ.1) GOTO 315
      WRITE(3,790)
790   FORMAT(/,20X,'FULL BORE FLOW ESTABLISHED.'/)
316    CONTINUE
      EN(2,IS)=B+(Q**2)/(2.0*G*AREA**2)
      F(2,IS)=RHO*Q*Q/AREA+GAM*AREA*B/2.0
      IF(IOUT.EQ.1) GOTO 317
      WRITE(3,205)SL,B,EN(2,IS),F(2,IS)
317    CONTINUE
      XL=PL-SL
      IS=IS+1
      DEP(2,IS)=B
      X(2,IS)=0.0
      SL=PL
      EN(2,IS)=EN(2,IS-1)
      F(2,IS)=RHO*Q*Q/AREA+GAM*AREA*(B/2.0)
      IF(IOUT.EQ.1) GOTO 3171
      WRITE(3,205)SL,B,EN(2,IS),F(2,IS)
3171  CONTINUE
      GOTO 900
900   CONTINUE
C
```

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C
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C
C     IDENTIFICATION OF JUMP POSITION BY EQUIVALENCE
C     OF THE F+M TERM.
      IF(F(1,1).LT.F(2,IS).AND.IOUT.EQ.0)WRITE(3,385)
385   FORMAT(/20X,'JUMP DROWNED AT L=0 AT TEST PIPE ENTRY',/)
      IF(F(1,1).LT.F(2,IS)) GOTO 800
      XP=0.0
      DELX=PL/500.0
103   XP=XP+DELX
      DO 102 I=1,100
      J=2
      IF(X(J,I+1).LE.XP.AND.X(J,I).GE.XP) GOTO 108
      IF(X(J,I+1).EQ.0.0) GOTO 103
102   CONTINUE
108   CALL INTER(X(J,I+1),F(J,I+1),X(J,I),F(J,I),XP,FX)
      J=1
      DO 104 K=1,100
      IF(K.GT.IM(2)) GOTO103
      IF(X(J,K).LE.XP.AND.X(J,K+1).GT.XP)GOTO 109
      GOTO 104
109   CONTINUE
      IF(F(J,K).GE.FX.AND.F(J,K+1).LE.FX)GOTO 110
104   CONTINUE
C
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CC
110   CONTINUE
      FP(1,1)=F(1,K)
      FP(1,2)=F(1,K+1)
      DP(1,1)=X(1,K)
      DP(1,2)=X(1,K+1)
      FP(2,1)=F(2,I+1)
      FP(2,2)=F(2,I)
      DP(2,1)=X(2,I+1)
      DP(2,2)=X(2,I)
      IP(1)=K
      IP(2)=I
      CALL SOLVE(DP(1,1),FP(1,1),DP(1,2),FP(1,2),DP(2,1),FP(2,1),
     1DP(2,2),FP(2,2),XJ,FJ)
C     CALCULATION OF DEPTH AND ENEPGY CHANGES AT THE JUMP.
      DO 49 K=1,2
      CALL INTER(X(K,IP(K)),DEP(K,IP(K)),X(K,IP(K)+1),
     1DEP(K,IP(K)+1),XJ,HJ(K))
      CALL INTER(X(K,IP(K)),EN(K,IP(K)),X(K,IP(K)+1),
     1EN(K,IP(K)+1),XJ,EJ(K))
49    CONTINUE
C
C
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```
      CHH=HJ(2)-HJ(1)
      CHE=EJ(2)-EJ(1)
      IF(IOUT.EQ.1) GOTO 318
      WRITE(3,107)XJ,HJ(1),HJ(2),EJ(1),EJ(2),FX,CHH,CHE
107   FORMAT(////,20X,'JUMP POSITION           =',F10.4,
     1' M FROM PIPE ENTRY.',
     1/,20X,'CONJUGATE DEPTHS      =  ',F8.4,' M UPSTREAM AND ',
     1F6.4,'M DOWNSTREAM.',/,20X,
     1'KINETIC ENERGY VALUE =  ',F8.4,'M UPSTREAM AND ',F8.4,
     1' M DOWNSTREAM.',/,20X,
     1'HYDROSTATIC+MOMENTUM = ',F9.4,' N.',/,
     1/,20X,'DEPTH CHANGE AT JUMP = ',E14.5,' M.',
     2/,20X,'ENERGY LOSS AT JUMP  = ',E14.5,' M.')
318   CONTINUE
      HUP(IC)=HJ(1)
      HDN(IC)=HJ(2)
      EUP(IC)=EJ(1)
      EDN(IC)=EJ(2)
      DJH(IC)=CHH
      DEJ(IC)=CHE
      CFPM(IC)=FX
      XJUMP(IC)=XJ
      IZ=0
      GOTO 800
C
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C
9010   CONTINUE
      IF(IOUT.EQ.0) GOTO 320
C     THIS OUTPUT SECTION IS ONLY USED IF IOUT=1,TABULAR
C     OUTPUT ONLY
      IF(ICON.EQ.2.AND.ICOUNT.EQ.0) WRITE(3,325)
325   FORMAT('1 PROGRAM RESULTS BASED ON TERMINAL CONDITIONS',
     1' IN THE APPROACH PIPE AND NORMAL FLOW DEPTH DOWNSTREAM',
     2' OF THE JUMP IN THE TEST PIPE.',//)
      IF(ICON.EQ.2.AND.ICOUNT.EQ.0)WRITE(3,321)
      I=IC
      IF(ICOUNT.EQ.20.AND.ICON.EQ.2)WRITE(3,325)
      IF(ICOUNT.EQ.20)WRITE(3,321)
      IF(ICOUNT.EQ.20)ICOUNT=0
      ICOUNT=ICOUNT+1
      IF(HN2(I).LT.HC2(I)) GOTO 370
      IF(HN2(I).EQ.0) GOTO 371
      IF(FEN(I).LE.CFPM(I)) GOTO 372
      WRITE(3,323)QT(I),B,RM,S1(I),HN1(I),TEN1(I),S2(I),HC2(I),
     1HN2(I),HEN(I),EEN(I),FEN(I),HUP(I),HDN(I),DJH(I),EUP(I),EDN(I),
     2DEJ(I),CFPM(I),XJUMP(I)
      GOTO 322
370   WRITE(3,380)QT(I),B,RM,S1(I),HN1(I),TEN1(I),S2(I),HC2(I),HN2(I)
```

```
      GOTO 322
371   WRITE(3,381)CT(I),B,RM,S1(I),HN1(I),TEN1(I),S2(I),HC2(I),HN2(I)
      GOTO 322
372   WRITE(3,382)CT(I),B,RM,S1(I),HN1(I),TEN1(I),S2(I),HC2(I),HN2(I)
      GOTO 322
322   CONTINUE
C
323   FORMAT(/5X,F4.1,F5.2,F6.3,F7.4,2F6.3,F7.4,3F6.3,F6.2,3F6.3,
     14F7.3,2F6.3)
380   FORMAT(/5X,F4.1,F5.2,F6.3,F7.4,2F6.3,F7.4,2F6.3,15X,
     1' JUMP IMPOSSIBLE AS HN<HC IN TEST PIPE.')
381   FORMAT(/5X,F4.1,F5.2,F6.3,F7.4,2F6.3,F7.4,2F6.3,15X,
     1' FULL BORE FLOW ESTABLISHED IN TEST PIPE.')
382   FORMAT(/5X,F4.1,F5.2,F6.3,F7.4,2F6.3,F7.4,2F6.3,15X,
     1' JUMP DROWNED AT L=0 AT TEST PIPE ENTRY.')
321   FORMAT(///5X,'  COMMON DATA  ','APPROACH PIPE DATA ',
     125X,'TEST PIPE DATA AND PROGRAM RESULTS.',//,
     25X,' Q.  DIA. MANN. SLOPE   HN  TERM.  SLOPE   HC    HN  ',
     3'ENTRY ENTRY ENTRY UPJUMP DOWN  DEPTH  ENERGY ENERGY ENERGY',
     4' JUMP  JUMP ',/,5X,'L/S  M.   COEFF (SIN)   M.  ENERGY',
     5' (SIN)   M.    M.  DEPTH ENERGY F+M  DEPTH  DEPTH CHANGE ',
     6'UPJUMP DOWN   CHANGE F+M.  POS. ',/,5X,
     728X,'  M.   ',19X,'  M.    M.    M.    M.    M.     M.  ',
     8'    M.    M.       M.    M.    M.',/)
320   CONTINUE
      GOTO 9011
901   CONTINUE
      READ(4,702)SHAPE
      IF(SHAPE.GT.0) GOTO 902
      END
C
C
C
      SUBROUTINE INTEF(A,B,C,D,X,Y)
C     SUBROUTINE INTER SIMPLY INTERPOLATES LINEARLY BETWEEN
C     TWO SETS OF DATA POINTS AND IS USED TO CALCULATE
C     JUMP DEPTH AND ENERGY CHANGES AS WELL AS POSITION.
      Y=B+(X-A)*(D-B)/(C-A)
      RETURN
      END
C
C
C
      SUBROUTINE SOLVE(X1,Y1,X2,Y2,X3,Y3,X4,Y4,X5,Y5)


C     SUBROUTINE SOLVE DETERMINES THE INTERSECTION POINT OF
C     TWO STRAIGHT LINES DRAWN BETWEEN FPM-X COORDINATES
C     IDENTIFIED AS LYING ON EITHER SIDE OF THE JUMP POSITION.
      A=(Y1-Y2)/(X1-X2)
      B=Y1-X1*A
      C=(Y3-Y4)/(X3-X4)
      D=Y3-X3*C
      X5=(D-B)/(A-C)
      Y5=A*X5+B
      RETURN
      END
C
C
C
C
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```
C
C
      SUBROUTINE BOUND(E,Q,B,HB)
      INTEGER SHAPE
      COMMON/CP2/SHAPE
C     SUBROUTINE BOUND CALCULATES THE ENTRY CONDITION TO THE
C     MILD SLOPE PIPE (IZ=2) BY REFERENCE TO THE ENERGY AT
C     DISCHARGE FROM THE STEEP SLOPE PIPE (IZ=1), OR SIMPLY
C     FROM THE ENERGY INPUT DATA IF THAT MODE IS CHOUSEN
C     BY THE INPUT OF ICON = 1 IN THE INITIAL READ STATEMENTS.
C     PIPE CROSS SECTION IS CONTROLLED BY THE VALUE OF
C     TERM SHAPE, 1=RECTANGULAR OR 2=CIRCULAR, IN THE INPUT.
      G=9.81
      IF(SHAPE.GT.1) GOTO 2
      Y1=0.0
      HB=Q/(B*(2.0*G*E)**0.5)
      DH=HB/200.0
      HX=HB/2.0
      DO 75 I=1,100
      IF(I.GT.1) Y1=Y
      HX=HX+DH
      Y=(Q**2)/(2.0*G)+((B*HX)**2)*(HX-E)
      IF(I.EQ.1)GOTO 75
      IF(Y1.GE.0.0.AND.Y.LE.0.0) GOTO 76
      IF(Y1.LE.0.0.AND.Y.GE.0.0) GOTO 76
75    CONTINUE
76    HB=HX
      GOTO 1
2     CONTINUE
      H=0.0
      EC1=0.0
      DELH=B/200.0
      PI=3.142
      R=B/2.0
3     H=H+DELH
      IF(H.LT.R) THETA=2.0*ATAN(SQRT(H*(B-H))/(R-H))
      IF(H.EQ.R) THETA=PI
      IF(H.GT.R) THETA=PI+2.0*ATAN((H-R)/(SQRT(H*(B-H))))
      AREA=((B**2)/8.0)*(THETA-SIN(THETA))
      EC2=H+(Q**2)/((AREA**2)*2.0*G)
      IF(EC2.LE.E.AND.EC1.GE.E) GOTO 4
      EC1=EC2
      GOTO 3
4     HB=H


1      CONTINUE
       RETURN
       END
C
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C
C
C
      SUBROUTINE CALC(H,DL)
C     SUBROUTINE CALC IS USED THROUGHOUT THE PROGRAM TO
C     DETERMINE THE FLOW-PIPE PARAMETERS SUCH AS FLOW
C     DEPTH,AREA,WETTED PERIMETER AS WELL AS BEING USED
C     IN THE BISECTION METHOD CALCULATION OF NORMAL AND
C     CRITICAL DEPTHS IN EACH OF THE PIPE LENGTHS.
C     IN THE CIRCULAR PIPE CROSS SECTION CASE IT ALSO
C     CALCULATES SUBTENDED ANGLE AND THE WATER SURFACE
C     WIDTH AS DEPTH CHANGES.
C     AS IN BOUND AND MAIN PROGRAM THE PIPE SHAPE IS DETERMINED
C     BY THE VALUE OF THE TERM SHAPE INPUT AS DATA.
      INTEGER SHAPE
      COMMON/CM1/P,Q,G,CON,SO,GAM,RHO,HCRIT,HNORM,AREA,PER,FPM,ENERG
      COMMON/CM2/SHAPE
      COMMON/CM3/IZ
      IF(SHAPE.GT.1)GOTO 1
      IF(IZ.EQ.3.AND.H.GE.B)H=B
      AREA=H*B
      PER=B+2.0*H
      HCRIT=1.0-(Q**2)*B/(G*AREA**3)
      HNORM=1.0-(Q**2)*CON/((AREA**3.333)/(PER**1.333))
      DL=HCRIT/(HNORM*SO)
      FPM=(GAM*AREA*H/2.0)+(RHO*Q*Q/AREA)
      ENERG=H+(Q**2)/((AREA**2)*2.0*G)
      GOTO 2
1     R=B*0.5
      PI=3.142
      IF(IZ.EQ.3.AND.H.GE.B) GOTO 20
      IF(H.LT.R) THETA=2.0*ATAN(SQRT(H*(B-H))/(B/2.0-H))
      IF(H.EQ.R) THETA=PI
      IF(H.GT.R) THETA=PI+2.0*ATAN((H-B/2.0)/(SQRT(H*(B-H))))
      GOTO 22
20    H=B
      THETA=2.0*PI
      AREA=PI*(B/2.0)**2
C
      PER=PI*B
      XO=B/2.0



      GOTO 21
22    CONTINUE
      AREA=((B**2)/8.0)*(THETA-SIN(THETA))
      PER=B*THETA/2.0
      T=2.0*((H*(B-H))**0.5)
      HCRIT=1.0-(Q**2.0)*T/(G*AREA**3)
      HNORM=1.0-(Q**2.0)*CON/((AREA**3.333)/(PER**1.333))
      DL=HCRIT/(HNORM*SO)
      XO=(2.0/3.0)*(B/2.0)*(3.0*SIN(THETA/2.0)-SIN(3.0*THETA/2.0))
     1/(4.0*(THETA/2.0-0.5*SIN(THETA)))
21    HBAR=XO+H-B/2.0
      FPM=GAM*AREA*HBAR+RHO*Q*Q/AREA
      ENERG=H+(Q**2)/((AREA**2)*2.0*G)
2     CONTINUE
      RETURN
      END
$BEND
```

APPENDIX 12

PROGRAM HYDSUM

PROGRAM HYDSUM

A full printout of program HYDSUM is included in this appendix. The program was written in Fortran for use on the NBS CBT Perkin Elmer 732 computer. No special facilities are required, single precision sufficient.

The program is designed to calculate the critical and normal flow depths based on pipe slope, cross sectional size and shape, flow rate and Manning coefficient. No flow chart is included as the program is directly copied from the early sections of HYDJUMP.

The output is in tabular form and presents critical and normal depths as functions of pipe slope and flow rate for set values of Manning coefficients. In addition (F & M) values based on normal flow depths are calculated and tabulated as functions of pipe slope and flow rate.

Sample data are included in this appendix.

All calculations are carried out in SI units and all data are input in these units with the exception of flow rate which is input in litres/s and converted in the program to m^3/s.

Sample DATA Program HYDSUM

Case 1 Tabulation of h_n, h_c, (F+M) for a range of 8 flow rates for circular and rectangular channels.

Line 1 SHAPE 1 = rectangular
2 = circular

Format I3
∇∇2

Line 2 T (diameter or width), RM(Manning coefficient), QMIN(lowest flow rate), DQ(flow increment) NI(N° of test pipe slopes), N2(N° of approach pipe slopes).

Format 4F10.4, 2I3
∇∇∇∇0.1500∇∇∇∇0.0150∇∇∇∇1.0000∇∇∇∇1.0000∇∇2∇∇3

Line 3 S1 test pipe slope, Format F10.4.
∇∇∇∇0.0025

Line 4 S1 test pipe slope, Format F10.4
∇∇∇∇0.0050

Line 5 S2 approach pipe slope, Format F10.4
∇∇∇∇0.5000

Line 6 S2 approach pipe slope, Format F10.4
∇∇∇∇0.7070

Line 7 S2 approach pipe slope, Format F10.4
∇∇∇∇0.8660

Line 8 SHAPE Format I3
∇∇1

Line 9 B, RM, QMIN, DQ, N1, N2
Repeat Line 2

Line 10 SHAPE
∇∇0 - indicates end of file.

```
$BATCH
C      HYDSUM CALCULATES VALUES OF HC AND HN TO DETERMINE
C      WHETHER JUMP FOMATION IS POSSIBLE, ALSO VALUES OF
C      F+M ARE CALCULATED TO INDICATE WHETHER THE JUMP IS
C      DROWNED ET PIPE ENTRY.
       DIMENSION QT(10),SLOPE(100),HNP(100,10),HCP(10),F(100,10)
       INTEGER SHAPE
       COMMON/CM1/B,Q,G,CON,SO,GAM,RHO,HCRIT,HNORM,AREA,PER,FPM,ENERG
       COMMON/CM2/SHAPE
       READ(4,702)SHAPE
702    FORMAT(I3)
       READ(4,600)B,RM,QMIN,DQ,N1,N2
600    FORMAT(4F10.4,2I3)
       QT(1)=QMIN
       DO 601 K=2,8
       QT(K)=QT(K-1)+DQ
601    CONTINUE
       I=0
       DO 602 J=1,N1
       I=I+1
       READ(4,603)S1
603    FORMAT(F10.4)
       SLOPE(I)=S1
602    CONTINUE
       DO 604 J=1,N2
       I=I+1
       READ(4,603)S2
       SLOPE(I)=S2
604    CONTINUE
       N3=N1+N2
       N4=N1
622    CONTINUE
       DO 605 I=1,N3
       DO 606 K=1,8
       Q=QT(K)/1000.0
       G=9.81
       RHO=1000.0
       GAM=G*RHO
       SO=SLOPE(I)
       CON=(RM**2)/SO
C      DETERMINATION OF CRITICAL AND NORMAL DEPTHS.
C      CALCULATION OF CRITICAL DEPTH.
       UP=B
       DN=0.0
       HC=UP/2.0
7      CONTINUE
       CALL CALC(HC,DL)
       IF(HCRIT)3,4,5
3      DN=HC
       GOTO 6
5      UP=HC
6      HCN=(UP+DN)/2.0
       IF(ABS((HCN-HC)/HC).LE.0.001) GOTO 8
       HC=HCN
       GOTO 7
8      HC=HCN
4      IF(HCONT.EQ.0.0)HCONT=HC
C      CALCULATION OF NORMAL DEPTH.
       UP=B
       DN=0.0
       HN=UP/2.0
9      CONTINUE
```

```
      IF(HNORM) 10,11,12
10    DN=HN
      GOTO 13
12    UP=HN
13    HNN=(UP+DN)/2.0
      IF(ABS((HNN-HN)/HN).LE.0.001) GOTO 14
      HN=HNN
      GOTO 9
14    HN=HNN
11    CONTINUE
      IF(HN.GE.B) HN=B
      CALL CALC(HN,DL)
      HNP(I,K)=HN
      HCP(K)=HC
      F(I,K)=FPM
606   CONTINUE
605   CONTINUE
      IF(SHAPE.EQ.1) WRITE(3,607)B,RM
      IF(SHAPE.EQ.2) WRITE(3,608)B,RM
607   FORMAT(1H1,1X,//,5X,'TABULATED NORMAL FLOW DEPTHS',
     1' FOR A RECTANGULAR CHANNEL OF WIDTH ',F10.4,' M. ',
     2'AND MANNING COEFF.',F10.4,/)
608   FORMAT(1H1,1X,//////,'      TABULATED NORMAL FLOW DEPTHS FOR A ',
     1'CIRCULAR CROSS SECTION CHANNEL OF DIAMETER ',F10.4,
     2' M. AND MANNING COEFF. ',F10.4,/)
      WRITE(3,609)(QT(K),K=1,8)
609   FORMAT(//,5X,'FLOW RATE = ',8F10.4,' L/S.',5X,
     1'PIPE DIA. OR',/,107X,'WIDTH M.')
      WRITE(3,619)
619   FORMAT(/50X,'NORMAL DEPTH M.')
      WRITE(3,610)SLOPE(1),(HNP(1,K),K=1,8),B
610   FORMAT(5X,'PIPE SLOPE',2X,/,7X,'(SIN)',/,5X,
     1F10.4,2X,8F10.4,10X,F10.4)
      DO 611 I=2,N1
      WRITE(3,612)SLOPE(I),(HNP(I,K),K=1,8),B
612   FORMAT(5X,F10.4,2X,8F10.4,10X,F10.4)
611   CONTINUE
      I=N4
      WRITE(3,613)
613   FORMAT(//,56X,'******',//)
      N5=N4+1
      DO 614 I=N5,N3
      WRITE(3,612)SLOPE(I),(HNP(I,K),K=1,8),B
614   CONTINUE
      WRITE(3,615)(HCP(K),K=1,8)
615   FORMAT(//,5X,'CRITICAL',4X,8F10.4,/,5X,'DEPTH M.',/)
      IF(SHAPE.EQ.1)WRITE(3,616)B,RM
      IF(SHAPE.EQ.2)WRITE(3,617)B,RM
616   FORMAT(1H1,1X,//////5X,'TABULATED VALUES OF F*M AT NORMAL ',
     1'DEPTHS IN A RECTANGULAR CHANNEL OF WIDTH ',F10.4,
     2' M. AND MANNING COEFF. ',F10.4,/)
617   FORMAT(1H1,1X,//////5X,'TABULATED VALUES OF F*M AT NORMAL ',
     1'DEPTHS IN A CIRCULAR CROSS SECTION CHANNEL DIAMETER ',
     2F10.4,' M. AND MANNING COEFF. ',F10.4,/)
      WRITE(3,609)(QT(K),K=1,8)
      WRITE(3,620)
620   FORMAT(/43X,'F*M VALUE AT NORMAL DEPTH, M.')
      WRITE(3,610)SLOPE(1),(F(1,K),K=1,8),B
      DO 618 I=2,N3
      IF(I.LE.N4)WRITE(3,612)SLOPE(I),(F(I,K),K=1,8),B
      IF(I.GT.N4)WRITE(3,612)SLOPE(I),(F(I,K),K=1,8),B
      IF(I.EQ.N4)WRITE(3,613)
```

```
618   CONTINUE
      READ(4,702)SHAPE
      IF(SHAPE.EQ.0) GOTO 621
      READ(4,600)B,RM,QMIN,DQ,N1,N2
      GOTO 622
621   CONTINUE
      END
      SUBROUTINE CALC(H,DL)
C     SUBROUTINE CALC IS USED THROUGHOUT THE PROGRAM TO
C     DETERMINE THE FLOW-PIPE PARAMETERS SUCH AS FLOW
C     DEPTH,AREA,WETTED PERIMETER AS WELL AS BEING USED
C     IN THE BISECTION METHOD CALCULATION OF NORMAL AND
C     CRITICAL DEPTHS IN EACH OF THE PIPE LENGTHS.
C     IN THE CIRCULAR PIPE CROSS SECTION CASE IT ALSO
C     CALCULATES SUBTENDED ANGLE AND THE WATER SURFACE
C     WIDTH AS DEPTH CHANGES.
C     AS IN BOUND AND MAIN PROGRAM THE PIPE SHAPE IS DETERMINED
C     BY THE VALUE OF THE TERM SHAPE INPUT AS DATA.
      INTEGER SHAPE
      COMMON/CM1/B,Q,G,CON,SO,GAM,RHO,HCRIT,HNORM,AREA,PER,FPM,ENERG
      COMMON/CM2/SHAPE
      COMMON/CM3/IZ
      IF(SHAPE.GT.1)GOTO 1
      IF(IZ.EQ.3.AND.H.GE.B)H=B
      AREA=H*B
      PER=B+2.0*H
      HCRIT=1.0-(Q**2)*B/(G*AREA**3)
      HNORM=1.0-(Q**2)*CON/((AREA**3.333)/(PER**1.333))
      DL=HCRIT/(HNORM*SO)
      FPM=(GAM*AREA*H/2.0)+(RHO*Q*Q/AREA)
      ENERG=H+(Q**2)/((AREA**2)*2.0*G)
      GOTO 2
1     R=B*0.5
      PI=3.142
      IF(IZ.EQ.3.AND.H.GE.B) GOTO 20
      IF(H.LT.R) THETA=2.0*ATAN(SQRT(H*(B-H))/(B/2.0-H))
      IF(H.EQ.R) THETA=PI
      IF(H.GT.R) THETA=PI+2.0*ATAN((H-B/2.0)/(SQRT(H*(B-H))))
      GOTO 22
20    H=B
      THETA=2.0*PI
      AREA=PI*(B/2.0)**2
      PER=PI*B
      X0=B/2.0
      GOTO 21
22    CONTINUE
      AREA=((B**2)/8.0)*(THETA-SIN(THETA))
      PER=B*THETA/2.0
      T=2.0*((H*(B-H))**0.5)
      HCRIT=1.0-(Q**2.0)*T/(G*AREA**3)
      HNORM=1.0-(Q**2.0)*CON/((AREA**3.333)/(PER**1.333))
      DL=HCRIT/(HNORM*SO)
      X0=(2.0/3.0)*(B/2.0)*(3.0*SIN(THETA/2.0)-SIN(3.0*THETA/2.0))
     1/(4.0*(THETA/2.0-0.5*SIN(THETA)))
21    HBAR=X0+H-B/2.0
      FPM=GAM*AREA*HBAR+RHO*Q*Q/AREA
      ENERG=H+(Q**2)/((AREA**2)*2.0*G)
2     CONTINUE
      RETURN
      END
$BEND
```

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The criteria governing the formation of a hydraulic jump in a partially filled fluid conduit downstream of a slope change are presented together with the necessary techniques to enable water surface profiles and jump location to be predicted.

Computer programs designed to model the conditions leading to jump formation under flow and channel scale conditions compatible with current drainage system design are presented.

The results of a wide range of test conditions in terms of jump formation and position downstream of a change in channel slope are presented together with a set of criteria to be used in evaluating whether a jump will occur for a given set of design conditions.

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building drainage; gradually varied flow; hydraulic jump; partially filled pipe flow.

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